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THE ALLOCATION OF RADIO FREQUENCIES

THE INTRODUCTION OF INDEPENDENT TELEvision in this country and the need to allocate frequencies for its television stations has, in the last year or so, called attention to the general problem of frequency allocation. Even though, as we believe, the allocation of various parts of the frequency spectrum has been carried out in the United Kingdom with wisdom and impartiality, and the views of all the important representative bodies and users have been taken into account, it is still desirable not only that justice be done, but that it shall be seen to be done. To accomplish this in the ever changing world of radiocommunication and radar, where entertainment, commerce, internal security, public communications, the safety of ships and aircraft, the requirements of the armed services, and, last but not least, the need to present the British way of life to foreign countries, have to be considered in the light of specialized technological considerations, is indeed a problem.

From time to time the broad pattern of frequency usage is revised and extended internationally at worldwide administrative radio conferences. The last such conference was held in Atlantic City in 1947, at which radical changes were made to the frequency allocation table agreed at the previous Cairo Conference of 1938, because the war had not only accelerated the existing uses of radio but also introduced many new and important applications for which no provision had specifically been made in the International Frequency Allocation Table. The Atlantic City Conference managed to rearrange and adjust the allocations to the various types of service—broadcasting, fixed, mobile, amateur—so that most of the low-frequency (30–300 kc/s) and the high-frequency (3–30 Mc/s) bands were allotted on a common basis throughout the world. Since then, administrations have been concerned with the difficult problems arising from the implementation of the agreement, difficult because the h.f. part of the spectrum was already filled to overflowing; individual stations were reluctant therefore to move from well-established assignments to others, which, although they might be for the good of the greater number of stations, involved new and different risks of interference, and increased risks where the extent of the allocation to particular services was reduced.

At frequencies between 30 Mc/s and 10 500 Mc/s, the revised upper limit of the international allocation of frequencies, the Conference sometimes found it convenient to agree on somewhat different allocations for the three regions into which the world is, for this purpose, divided. (Region 1 is broadly Europe and Africa; Region 2, the Americas; Region 3, Asia and Australasia.) This variation was possible because at frequencies above 30 Mc/s the limitations of transmission enable the regions (and areas within the regions) in some measure to plan independently and arrange the pattern of allocation to suit their differing needs.

Some 72 countries became signatories to the Atlantic City Radio Regulations, and in so doing accepted many rules for the assignment and use of frequencies. Particularly important are the rules for minimizing interference between stations. Thus these countries undertook to assign frequencies so as to avoid causing harmful interference with services carried on by stations that use frequencies assigned in conformity with the Allocation Table and are thereby entitled to international protection from harmful interference; and not to assign any frequency in derogation of the Table except on the express condition that harmful interference would not thereby be caused to services operating in full accordance with the Regulations. Moreover where a band of frequencies is allocated to different services in adjacent regions or sub-regions, the basic principle is *the equality of right to operate*. Without the universal acceptance of this important principle, the Conference might have failed to agree on a common pattern of frequency usage.

Thus, considering now the national scene, in one form or another Governmental control of radio transmissions is clearly essential, not only to see that international agreements are observed, but to ensure that the limited frequency space available is used as efficiently as possible.

To this end, the Post Office and the other Government Departments concerned in frequency allocation matters consult with the users and the radio industry. Advisory committees, on which the various interests are represented, have been formed to study the problems of particular services such as television and mobile radio, and to advise the Postmaster General on their needs.

Some voices have been raised in protest at the part played by the Post Office in these matters on the ground that, because it is also responsible for conducting certain oversea and domestic radio communications, it cannot be impartial. Although those who have had much to do with the professional and administrative branches of the Civil Service may well feel that this is not so, there is in this argument an element of justification that might make a change desirable. In the United States frequency allocations for civil purposes are also in the hands of a Government body, the Federal Communications Commission, which formulates rules and orders governing the use of radio. Public notice of proposed new rules is given, and interested parties invited to file comments; public hearings may follow with counsel briefed to represent interested parties. Nevertheless allocations for other than civil needs do not appear to fall inside the scope of the Commission's activities. Maybe for this country the use of independent chairmen of advisory committees, and the inclusion in them of some members having no sectional interest in frequency allocation, is a suitable compromise for eliminating such criticism as arises and is in line with British traditions.

Turning now to more general questions, one at times hears the criticism that, although parts of the spectrum are very heavily overloaded, others appear little used. Indeed, in a measure, this is true, because some frequency bands are reserved, often by international agreement, for services which are still in their infancy, while others carry services which are already well developed. At other times, but not necessarily from different sources, one also hears criticism that what was a little used part of the spectrum has been allocated to meet the needs of another service even if only on a temporary basis. These two criticisms are typical of the views that immediately spring to the minds of those who are new to frequency-allocation matters; but clearly they are inconsistent with one another, and scarcely helpful.

Whether in fact the spectrum is being unnecessarily overcrowded with radio transmissions is another matter and one worthy of the most serious consideration. Most people accept that there are certain communications, nowadays regarded as essential, for which there is virtually no alternative to radio: domestic broadcasting and television, communication to, and navigational aid for, ships and aircraft, and presumably really long-distance telephone communication. However with the laying of the new transatlantic telephone cable, which will shortly provide thirty-six telephone channels between the United Kingdom and North America, it is to be hoped that administrations will consider very seriously the use of similar cables in all parts of the world. Indeed it is believed that other such projects are already in mind if not in hand. An extension of the use of submarine cables with repeaters would have the advantage not only of improving the reliability and quality of long-distance telephone, and indeed of telegraph, communication, but would also relieve the r.f. spectrum of a substantial load. For those services which necessarily will continue to use radio, much can be done to relieve congestion in the spectrum—and thereby minimize the risk of harmful interference—by improving the performance of radio equipment. Improved techniques, reducing the bandwidth occupied by individual transmissions, and reduction of the permissible frequency tolerances, are all necessary to permit closer spacing between adjacent channels, with a consequent increase in the number that can be accommodated. Benefit must also be secured from the greater suppression of all unnecessary radiation from transmitters, thus necessitating more nearly linear characteristics in both modulators and amplifiers. Reduction of harmonics radiated by transmitters is very desirable, since harmonics of high-power transmitters can be particularly disturbing if they fall in bands used by low-powered services. Improved selectivity in receivers can do much to prevent interference and to promote efficient use of the spectrum; inadequate selectivity coupled with receiver distortion can result in interference from transmitters, operating properly, far removed from the frequency that it is desired to receive. Of more fundamental importance are investigations into new methods of coding signals so that the bandwidth required approaches more closely to the theoretical minimum necessary for the transmission of the information; the further development of adjustable ray-selecting aerial systems for reception; and if possible the development of these aerial systems for transmission as a means of avoiding interference which might otherwise occur.

In this brief survey of frequency allocation no easy solution is foreseen for the congestion existing to-day in certain parts of the r.f. spectrum. Many of the present difficulties arise, directly or indirectly, from tension existing in world affairs. Improvements in the performance of radio equipment will increase the use that can be made of the spectrum and so relieve congestion, but economic considerations are often allowed to stand too long in the way of such improvements, even though no great cost may be involved and an increase in effective service time secured. There can surely be no doubt that in the long run the cost of better performance will prove a wise investment, and that there is still much scope for the deployment of the skill of the radio engineer.

FERRITES—*The Forthcoming Convention at The Institution*

A Convention on Ferrites will be held at The Institution from the 29th October to the 2nd November this year. Professor F. Brailsford, a member of the Convention's organizing committee, here introduces the subject and the scope of the Convention. It is worth recalling that this brief article has been written as a result of a suggestion made by Professor G. F. Nicholson in last February's issue of the Journal. One of Professor Nicholson's points was that more non-specialists would attend a specialized Convention if they could be lucidly introduced to its subject-matter. After reading Professor Brailsford's article some members who have not yet registered for the Convention may decide that they would like to attend it; it would be helpful if they would apply to the Secretary for a registration form without delay.

By **PROFESSOR F. BRAILSFORD,**
PH.D., B.SC.(ENG.), WH.SC., MEMBER

FERRITES are literally as old as the hills, and the subjects of electricity and magnetism are at least as old as the ancient Greeks. The philosopher Thales in the 6th century B.C. demonstrated the electrostatic attraction between rubbed amber and light objects, while, a century or so later, Socrates discussed the magnetic attraction of a lodestone which enabled it to pick up iron rings. The delightful tale is told that magnetism was, in fact, discovered by a Cretan shepherd called Magnus who one day found himself rooted to the rocks by the iron nails of his shoes. This may not be true, but it is most probable that man first became aware of magnetism through the lodestone. In that event then our knowledge of magnetism began with a ferrite. Moreover, the first practical application of magnetism, namely in the maritime compass, also employed a ferrite. We find that, in England in the 13th century, Peter Peregrinus showed how to make a compass by floating a lodestone in a wooden cup in a bowl of water, and of this device he wrote:

> If a thousand times you turn the stone away from that position, a thousand times will it return by the will of God.

We may consider the modern ferrites to be a scientific development of magnetite, the material of the lodestone.

At The Institution's forthcoming Convention on Ferrites in London, some forty or fifty papers dealing directly with the ferrites themselves and their applications in electrical engineering will be presented and discussed. The Convention will be an international gathering, for, in addition to papers from British authors, there will be many original contributions from well-known scientists and engineers from oversea, particularly from Holland, France and the United States.

An introductory lecture on the first day of the Convention will be given by Dr. Willis Jackson. As with the recent Convention on Digital-Computer Techniques, it will be necessary to run parallel sessions on most days in order to provide time for authors to be heard and for subsequent discussion. There will also be an exhibition of ferrite materials and associated equipment.

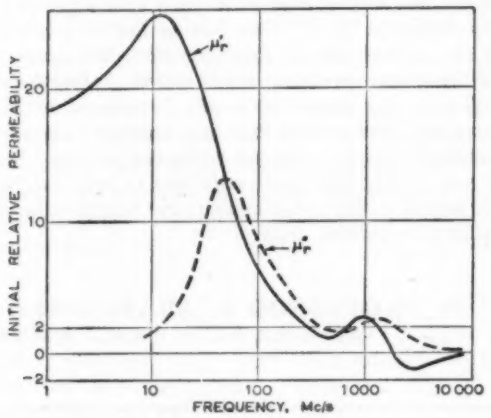
What, in fact, are the ferrites, and why this great interest in their properties and applications?

A chemical definition of the word *ferrite* is to be found in the Shorter Oxford English Dictionary, namely 'A combination of ferric oxide with a metallic oxide more basic than itself, as barium ferrite, $BaFe_2O_4$'. In the last eight or nine years the term has come to have a particular significance to electrical engineers, since it embraces a new class of useful and artificially-produced magnetic materials. The ferrites in general contain essentially iron and oxygen, and the useful ferrites have deliberate additions of one or more other elements, particularly, e.g., manganese, nickel or zinc. Apart from the ferromagnetic properties of these compounds they may also be made to have the supreme advantage—over the ferromagnetic metals and alloys—of exceptionally high electrical resistivity. This enables ferrites to be used in the solid form, with no laminating or powdering, at the highest frequencies and without the prohibitive eddy-current losses and skin effects which would occur with metals.

The ferrites are hard ceramic substances with a cubic crystalline structure. Crystals of the natural mineral magnetite with the chemical composition Fe_3O_4, which may be written as $FeO.Fe_2O_3$, have an initial relative magnetic permeability of about 10, and this value may be raised about seven times by purifying the material. Other simple ferrites may be prepared by mixing powdered oxides in the correct proportion and then sintering and heat treating; in this process some of the iron of the compound Fe_3O_4 is replaced by another metallic element—e.g. manganese ferrite may be produced with the formula $MnFe_2O_4$ or $MnO.Fe_2O_3$. The various ferrites may also be combined together since they form solid solutions with each other, and the materials of greater use and interest are such mixed ferrites. Manganese-zinc ferrites, for example, may have an initial relative permeability of about 1 000 with an electrical resistivity of the order of 100 ohm-cm, while nickel-zinc ferrites with a lower permeability may have an electrical resistivity of about 10^5 ohm-cm. The highest electrical resistivity obtainable in a ferromagnetic alloy is less than 10^{-4} ohm-cm, so that the ferrites are superior to the metals in this respect by a factor of from 10^6 to 10^9. These figures lend point to the statement already made

that the ferrites are free from the complications of induced eddy-currents even at the highest frequencies.

Apart from the practical usefulness of the ferrites, they are also of great academic interest in a number of respects. The fact that the electrical resistivity is so high has enabled measurements to be made of their magnetic properties over a range of frequencies from zero up to over 20 000 Mc/s. When the permeability is plotted against frequency, humps appear on the curve (Fig. 1).



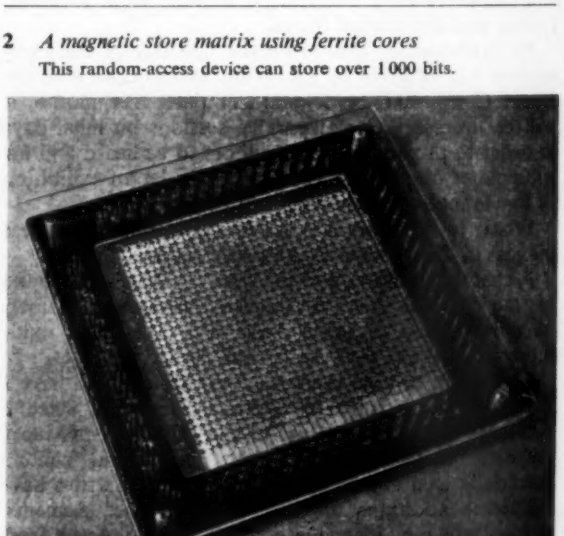
1 *Real part μ_r' and imaginary part μ_r'' of the complex initial permeability of a ferrite in relation to frequency, showing resonances at approximately 50 and 1200 Mc/s*

As the frequency increases from a low value the real component of the permeability increases, for some materials, to a maximum in the region of 10 Mc/s. It then falls rapidly to a relatively low value but another maximum occurs at about 1000 Mc/s, after which this component of the relative permeability may fall below zero and become negative. Corresponding humps appear in the loss curves.

The resonance at the lower frequency is reminiscent of the damped vibrations in a mechanical system and may in fact be associated with the inertia and movement of ferromagnetic domain boundaries in the material. The resonance at the higher frequency is explained in another way. If, as is generally supposed, the elementary magnet in any material is the spinning electron, this will have magnetic properties because of the electron's spinning charge, and gyroscopic properties because of its spinning mass. In the presence of a steady magnetic field or its equivalent, the axes of the spinning electrons will precess about the direction of the applied field just as a spinning top will precess when a torque is applied to it. The speed of precession depends upon the steady field strength. If now, an alternating field synchronous in frequency with the precessional angular velocity is applied, the resonance effects already mentioned will occur. Measurements on the ferrites therefore enable some knowledge of the fundamental processes which are common to all ferromagnetic materials to be obtained. A number of papers at the Convention will deal with these phenomena.

In iron and other ferromagnetic metals it is known that there is a domain structure. Each domain is magnetically self-saturated owing to internal forces of interaction between the spinning electrons which are responsible for the magnetic moment of the individual atoms. These forces cause the axes of the atomic magnets to be parallel with one another in each domain. If a strong magnetic field is applied to the metal the magnetic axes of the domains may also be pulled into alignment so that the observed magnetic saturation value of the material is the same as that of the individual domains. Iron, for example, has a saturation value of a little over 21 000 gauss. On the other hand, magnetite Fe_3O_4, which is again made up of domains, has a saturation value of only about 6000 gauss. In magnetite, all the iron ions are, in fact, not contributing directly to the magnetic saturation, for if they all made their maximum contribution, magnetite would have a saturation value nearly as high as that observed for metallic iron. Fe_3O_4 might be called an iron ferrite and, with the exception of manganese ferrites, the other ferrites have still lower saturation values. It is believed that in magnetite the magnetic axes of two of the three iron ions in the molecule are parallel and with their magnetic moments pointing in the same direction, but that the magnetic moment of the third iron ion points precisely in the opposite direction and is said to be *antiparallel*. The resultant magnetic moment of the molecule is therefore a difference and is due, in effect, to one ion only. In some chemical compounds the antiparallel arrays of ionic magnets are equal and opposite and this is a condition called *antiferromagnetism*. This is in fact what happens in those ferrites which have what is called a normal spinel crystal structure such as the zinc and cadmium ferrites, and these materials taken

2 *A magnetic store matrix using ferrite cores*
This random-access device can store over 1000 bits.



alone have no useful magnetic properties. However, in the useful ferrites, which, like magnetite, have an inverse structure, the opposing arrays are unequal so that the domains have a resultant magnetic saturation value and magnetic properties similar to those of the ferromagnetic metals. This phenomenon is known as *ferrimagnetism*. A theory has been formulated and simple rules put forward to determine the saturation value of a ferrite in terms of its chemical and crystal structure. The predicted and observed values agree reasonably well for a number of ferrites, but this agreement is not always found. In fact the physical basis of ferrimagnetism is an abstruse and difficult subject. A number of papers will be presented to the Convention on this aspect of ferrites, although most electrical engineers may find the mathematics and physics of this discussion more than a little difficult. However, the power engineer in particular, designing and operating rotating machines and transformers, is interested in the possibility of producing materials magnetically superior to iron or silicon–iron. The ferrites already have the advantage of negligible eddy currents. If they could be synthesized to be ferromagnetic rather than ferrimagnetic, materials might be obtained with a magnetic saturation value comparable to or even greater than that of metallic iron. The papers and discussions on this aspect of ferrites will therefore be followed with great interest.

The present applications of ferrites lie, however, with communication and with computers. About two-thirds of the papers to be presented to the Convention will deal with actual or envisaged applications and with problems arising from them. The materials are of great interest in connection with waveguides and microwave techniques. A considerable part of the time of the Convention will be taken up with papers and discussions on microwave applications. Ferrites may be made to have almost rectangular hysteresis loops, and such materials are useful in magnetic store systems for digital computers and in switching circuits. There are applications also in radio and television receivers and in carrier frequency work. All these subjects will be dealt with. We may look forward to an instructive if strenuous five days and to the privilege of meeting and hearing many distinguished workers in the field from at home and abroad.

La Conversazione di nuovo

A Festival Setting for The Institution's Summer Entertainment

THE evening of the 21st June 1956 saw the Royal Festival Hall accommodating an event whose name must have had a ring unfamiliar to its walls, used though they doubtless are to the Italian of the opera singer or of the conductor rehearsing an orchestra that is missing the composer's *cantabile* or *con espressione*. Preparations for The Institution's Conversazione, with its galaxy of technical exhibits, may indeed have made the Hall cock a more than usually quizzical eye at the dignified and well-proportioned red-brick building that lies opposite it across the waters of the Thames. But in the event what an excellent assembly-place the Festival Hall made for this major social event in The Institution's calendar—the first Conversazione to be held since 1948, when members and guests gathered together among the show-cases and dioramas of the Science Museum. The Hall's main auditorium, its foyer disguised as a ballroom, its riverside balconies and roof gardens, its rooms and promenades housing electrical exhibits, its buffets and its bars—they all served to charm, interest and refresh more than 2000 members and guests who thronged them. Admirably designed inside, the Festival Hall is, as we soon discovered, an admirable place in which to hold a scientific party.

The evening's programme began about 7.45 p.m. with a reception by the President and Lady Nelson in the upper foyer, a balcony above the main ground-floor space. Sir George and Lady Nelson are indefatigable on an occasion of this kind and succeed in making each member feel that it is he and his lady whom they are really glad to see. With no internal doors to break up the

The President greets Mr. and Mrs. Rylands

sweep of the foyer we might if we wished, after being received, stand on the balcony and look for friends in the procession that was slowly mounting the stairs to meet the President—a genial, if lazy, pastime that is usually denied one at large gatherings.

After the reception, we could spend our time viewing electrical exhibits on the upper floors of the building, dancing in the foyer, or listening to a vocal and instrumental concert in the main auditorium. Most of us

Members and guests looking at an exhibit of trunk dialling which was used in the Faraday Lecture

probably enjoyed during the evening something of each treat in turn, sandwiching them with conversations at casual meetings, and with visits to the buffets—to sample, among other good things, the time-honoured strawberries and cream—when in the course of strolling up and down and round the Hall we found ourselves near them.

To those who are not regular concert-goers, the layout of the Festival Hall can be a little confusing, but on the 21st June we were armed with ample geographical information in the printed programme of the Conversazione. Members and guests flowed freely through the promenades where the exhibits were staged, and in and out of the auditorium between the items of the concert, although this attracted a crowd more static than those to be found elsewhere in the building. The whole auditorium was ours for the nonce, and delightful it was to be able to pick a seat at will from the stalls or boxes without tickets or congestion.

The concert hall itself is well soundproofed, but in the promenades and open spaces that lie around it there were other musical sounds to claim our attention—some from live exhibits of electro-acoustic recordings, the most compelling perhaps from an orchestra, which was stationed at one end of the main foyer. Here members and ladies danced *con spirito*. Though situated only just inside the expanse of doors which form one of the entrances to the Hall, the foyer makes an admirable ball-room; all the dancers obviously relished the excellent surface and spaciousness of the floor. The dancing continued to midnight, when the evening's entertainment officially ended.

Elsewhere in the building, on the third and fifth floors, a hundred and more scientific and technical exhibits were on show—to catch our interest by illustrating notable and recent advances in electrical science and engineering. Some were in the Recital Room, normally used for chamber music; others were along the promenades that are a feature of the building. They varied from the playful and light-hearted, such as the echo well and the machine for playing nim, to the rather serious, such as an electromagnetic pump for use with nuclear reactors, and apparatus for the measurement of power at centimetre wavelengths.

All the exhibits had been generously contributed for the evening by members of The Institution in industrial firms or Government establishments. To allow the Festival Hall to be used for its normal activity on the evenings before and after the Conversazione, many of those installing and dismantling the equipments worked through the night. Their efforts were well rewarded, for the exhibits were beautifully displayed, and one or two, such as a joint Post Office and Science Museum exhibit depicting submarine telegraph and telephone cables, almost looked as though they were a permanent part of the Festival Hall's furniture.

A closed-circuit television demonstration, which was contributed by the President, used cameras and monitor tubes at various points throughout the building. Members and guests could therefore watch others at the Conversazione enjoying themselves in different parts of the Hall. Such an arrangement, or variations on it, is now becoming fairly common at Institution functions. One cannot tell whether it will outlive its novelty to become a usual feature of large gatherings, but its merit for one on the scale of the 1956 Conversazione is that it enables people to amuse each other unwittingly. Lack of privacy? Of course, but that is part of the interest.

Other noteworthy exhibits included a demonstration by the Meteorological Office of the application of facsimile telegraphy to weather forecasting, an exhibit of silicon and germanium single crystals, electron irradiation of materials, a model of a 25 MeV linear electron accelerator, and a demonstration of automatic process control. Perhaps a fair comment on the exhibits is that there was almost too much meat in them; those that had serious engineering information to convey far outnumbered those whose main purpose was to interest the layman. As a whole the exhibits therefore found a larger public among members than their guests.

But of course, it is only right that there should be tangible evidence of electrical science and engineering at the gathering. The name 'Conversazione' guarantees intellectual interest. It was moreover a gay, friendly occasion; Savoy Place might not be far from us or our minds, but for one night we were on the South Bank—*con allegrezza.*

Engineering Manpower

By E. R. PATRICK, PH.D., B.ENG., ASSOCIATE MEMBER

A revised version of the Chairman's Address given to the North Staffordshire Sub-Centre in October 1955

To secure sufficient of the expanding world trade to pay for her necessary imports, and to achieve the hoped-for rise in her standard of living, Great Britain must keep in the forefront of scientific progress and of the continued evolution towards automatic plant for making materials, machines and consumer goods; and she must expand her supplies of materials and energy. The most critical factor in all these developments will be manpower. Progress will be dependent on the availability of even more highly trained men and women at the top, middle and especially at the lower, levels. An indication of the magnitude of impending developments is given by the Government programme for nuclear power, which aims at increasing the total generating capacity from 20 000 MW in 1954 to 57 000 MW in 1975. This entails the construction of not only power plants but also apparatus to utilize the anticipated 200% increase in demand for electrical energy. At the same time every effort must be made to be the first country to export nuclear plant, possibly with the staff to handle it.

The Barlow Report foresaw a growing demand for technologists. The recommended expansion in supply has been reached and still the demand is both unsatisfied and increasing. Moreover, the needs of industry must be considered in their entirety. The shortage of all classes of staff, technicians and craftsmen, as well as scientists and technologists, is acute and will continue so.

The Distribution of Male Manpower

Evolutionary progress is fundamentally concerned with engineering in all its forms: electrical engineering, for example, can develop only in step with the construction of civil works and factories, the production of materials, the manufacture of machines and goods, and the transport and distribution of the products. Consequently, it is the distribution of males—boys and men—which is of prime importance. Table 1 gives the estimated distribution of males in civil employment in Great Britain, adjusted to include those

Table 1. Distribution of Males Employed in Great Britain, May 1954

	ALL MALES		BOYS UNDER 18	
	Number	Percentage	Number	Percentage
	$\times 10^3$		$\times 10^3$	
Electrical machinery and goods	394			
Electricity supply	172			
Electrical contracting	68			
Total in electrical industry	634	4	35	5
Metal manufacture	489			
Machine and engineers' tools	87			
Ordnance and small arms	49			
Other mechanical plant and goods	1015			
Vehicles and aircraft (excluding garages)	741			
Metal goods	317			
Precision instruments, etc.	85			
Total in non-electrical engineering industry	2783	18	146	21
Garages	250			
Gas and water supply	165			
	415	3	27	4
Total in engineering industry	3832	25	208	30
Building and civil engineering	1325	9	68	10
Non-engineering goods	2547	17	136	19
Transport, distribution and miscellaneous	3580	24	155	22
Mining and quarrying	851	6	43	6
Agricultural, forestry and fishing	932	6	55	8
Professional and public services	1930	13	33	5
Ex-Servicemen unclassed	7			

May 1955				
15 155	**Total in civil employment**	15 004	100	698	100
120	Wholly unemployed	162			
791	H.M. Forces	818			
16 066	**Total working male population**	15 984			

self-employed, for May 1954. The figures show that 25% of all boys and men were employed in the total engineering industry covering the subjects listed. Many engineers, technicians, and craftsmen are also engaged in the other groups. The manufacture of other goods absorbs 17% of all employed males, so that 42% are employed in the engineering and manufacturing industries, which, compared with only 6% engaged in agriculture, forestry and fishing, emphasizes the exceptionally high industrialization of Great Britain. Recent figures for 1955 show slight increases in the percentages for industry.

Table 2 gives the distribution of boys, under 18 years of age, entering employment for the year 1954, the latest year for which figures have been issued. The total number for this year was lower than would normally be expected, mainly because many school-leavers at Christmas, 1953, found jobs before the New Year, whereas many school-leavers at Christmas, in 1954, did not enter employment till January 1955. However, the figures will be appropriate to the years 1956 and 1957, when the numbers in the age groups entering industry will be reduced by some 10000 boys a year, owing to reduction in the relevant birth rate. Subsequently the number of school-leavers each year will increase to reach a peak—corresponding to the birth-rate bulge—in 1962–63, when it will be about 50% more than at present. Thereafter the number will fall fairly rapidly. As the peak is approached, industry will be able to afford to accept the raising of the school-leaving age to 16. However, it will be difficult for education authorities to find places and staff to cope with the extra pupils corresponding to the birth-rate bulge, even without raising the school-leaving age. Already there is a distinct trend for boys to stay longer at all schools. At the retirement end the effect of the peak of the rise in birth rate before the First World War has still to be reached.

When comparing the figures in Table 1 with those of Table 2, one should note that 'Boys under 18' includes boys of 17 who entered at 15 or 16, and boys of 16 who entered at 15. The figure of 30% in Table 1 for boys under 18 in engineering compares well with the 29·4% for those entering engineering which is given in Table 2. The difference between the 30% of boys under 18 and the 25% of all males in engineering is explained partly by the large percentage entering engineering at 15 and partly by the trained engineers and technicians who later transfer to other groups. In the professional and public services group Table 1 gives 13% for all males and only 5% for boys under 18. The explanation of

Table 2. Boys aged 15, 16 and 17 entering Employment in Great Britain in 1954

	Number	Total percentage ages 15–17	Percentages of total entering employment							
			At age 15				At age 16–17			
			A	C	O	Total	A	C	O	Total
	$\times 10^3$									
Total engineering	76·1	29·4	13·3	1·0	10·0	24·3	3·7	0·5	0·9	5·1
Building	24·3	9·4	5·8	0·2	2·4	8·4	0·7	0·1	0·2	1·0
Non-engineering	48·2	18·7	4·2	0·9	11·2	16·3	0·9	0·6	0·9	2·4
Transport, etc.	56·5	22·0	2·4	1·3	14·6	18·3	0·9	0·9	1·9	3·7
Mining, etc.	11·8	4·5	0·5	0·1	3·7	4·3	0·1	—	0·1	0·2
Agriculture, etc.	24·0	9·2	0·5	—	7·4	7·9	0·2	—	1·1	1·3
Professions, etc.	17·5	6·8	0·8	1·0	0·9	2·7	1·3	2·2	0·6	4·1
Total	258·4	100·0	27·5	4·5	50·2	82·2	7·8	4·3	5·7	17·8
			32·0				12·1			

A: Apprentices. C: Clerks. O: Others.

Table 3. Typical Distribution of Schoolboys

	ENGLAND AND WALES					GREAT BRITAIN
	At age 14		Percentage of the number at age 14 still at school			Estimated number
	Number	Percentage	Age 15	Age 16	Age 17	
	$\times 10^3$					$\times 10^3$
Grammar-school stream*	68·5	25	23·0	15·0	8·8	78
Technical-school stream	19·2	7	5·8	1·2	0·1	22
Modern-school stream	186·3	68	4·0	0·5		213
Full-time at technical colleges ..				1·2	1·1	
Total	274·0	100	32·8	17·9	10·0	313
Left at age 15			67·2%			210
Left at age 16 and 17				22·8%		72

* Including independent and direct-grant schools.

this large difference is partly that nearly two-thirds of the entries to this group under 18, as shown in Table 2, enter over 16, and partly that there is a comparatively large intake over the age of 18.

The flow of entrants from school to-day, either direct into industry or into colleges—and indeed the intake into schools—is the raw material of the most essential product of every industrial undertaking: men who are trained to make the best use of their talents and who enjoy serving the community in their daily work as well as their leisure. Schoolboys 15 years old now and proceeding to industry or to higher academic studies provide the trained men of 7–15 years hence, i.e. of 1962–1970, depending on the degree of knowledge and training for which they are suited. When they have left school their training and outlook are the joint responsibility of engineers in industry and of engineers in universities and technical colleges. Boys of five entering school will provide the trained men of 17–25 years hence. This brings us to 1980, by which time the Government hopes to have doubled the standard of living, a feat which can be attained and upheld only by an adequate supply of skilled engineers, technicians and craftsmen up-graded in all their levels compared with to-day.

Distribution in Schools

Table 3 indicates a typical distribution into the three main streams of boys in English and Welsh schools and the proportions remaining at school at ages 15, 16 and 17 expressed as percentages of all boys in the age group at 14. The figure for the grammar-school stream includes direct-grant and independent schools. From experience of the technical attainment of engineering apprentices, it would appear that the division line at 32% for the grammar-school plus technical-school stream and 68% for the modern-school stream cannot usefully be altered much. Possibly 6% are doubtfully placed in the secondary grammar and technical schools while there may be some 3% in the secondary modern schools who could take more academic studies. It is questionable whether any different system of sorting at 11 plus could improve the division. About 0·7% of the boys in the modern-school stream are attaining Ordinary National Certificate standard or above. There are provisions for transfer from secondary modern schools at 13 plus.

The ratio of the age groups in England plus Wales, and in Scotland, is about 7 to 1. The Scottish education system differs from that of England and Wales, and the statistical data is not set out in the same way, but some 30% of an age group in Scotland take senior secondary courses in which technical subjects can be taken. Table 3 has been extended on the right to include Scotland, assuming the same division as for England and Wales.

The Flow into Employment

About 90% of all boys enter industry under 18 years of age, and Table 4 has been devised from Tables 2 and 3 to

Table 4. Boys aged 15, 16 and 17 entering Employment in 1954 in Relation to all Boys in an Age Group

The figures, which refer to Great Britain, are percentages of all the boys in an age group comprising approximately 313 000 boys

	Age 15–16			Age 16–17			Age 15–17		
	G & T	M	Total	G & T	M	Total	G & T	M	Total
Engineering									
Apprentices	2·8	9·2	12·0	3·2	0·1	3·3	6·0	9·3	15·3
Clerks	0·2	0·7	0·9	0·5	—	0·5	0·7	0·7	1·4
Others	0·2	8·8	9·0	0·6	0·2	0·8	0·8	9·0	9·8
Total	3·2	18·7	21·9	4·3	0·3	4·6	7·5	19·0	26·5
Other careers									
Apprentices	2·7	10·1	12·8	3·5	0·2	3·7	6·2	10·3	16·5
Clerks	0·9	2·2	3·1	3·3	0·1	3·4	4·2	2·3	6·5
Others	0·3	35·9	36·2	4·0	0·3	4·3	4·3	36·2	40·5
Total (all careers) ..	7·1	66·9	74·0	15·1	0·9	16·0	22·2	67·8	90·0

G & T: From grammar and technical schools. M: From modern schools.

Table 5. Boys not employed till Age 18 or Over in relation to All Boys in an Age Group

The figures, which refer to Great Britain, are approximate percentages of all the boys in an age group comprising approximately 313 000 boys

	All activities		Engineering only
Entering universities			
Technology	0·7		0·7
Science	1·0		
Other studies	2·8		
	——	4·5	
Entering technical colleges (full time)			
Engineering	0·35		0·35
Other technologies	0·13		
Science	0·22		
Art, commerce, etc.	0·40		
	——	1·1	
Teachers training colleges		0·8	
Entering employment			
Engineering	0·25*		0·25*
Other employment	3·35		
	——	3·6	
Total entering colleges and industry over 18		10·0	1·30

* The true figure may possibly be less than this.

show the flow of boys under 18 years of age into industry from the grammar-school and technical-school streams, and from the modern-school stream, expressed as percentages of all the boys in the age group at 14. In compiling these figures, allowance has had to be made for differences in the grand totals of Tables 2 and 3 owing to Table 2 being based on the calendar year and Table 3 on the academic year; for the effect of those leaving schools at Christmas; and for the flow, including some from modern schools, to technical colleges. The figures for engineering comprise all the sections as listed for the total engineering industry in Table 1; nearly four-fifths of engineering apprentices enter industry at 15–16 years of age. There may subsequently be some interchange between the boys entering engineering as apprentices and as 'others'.

Table 5 gives an approximate apportionment of the 10% of all boys not entering employment or colleges until 18 years of age or over. The combination of Tables 4 and 5 is an attempt to provide a complete flow pattern for Great Britain of the boys in an age group. All the figures in both tables, and the percentages quoted below, are percentages of the whole annual flow from schools based on a stable total of 313 000 boys in each age group. The flow pattern can be regarded only as a rough guide, for the figures are derived from statistics difficult to correlate, although showing in themselves a certain stability or trend from year to year. The figures in Table 5 have been given as they would be if no National Service occurred before entry to full-time college courses or employment. There will be some flow between industry and colleges among those over 18. The university figures are for all male students in Great Britain entering universities, but the figures for those at technical colleges are for full-time students at these colleges at 18 plus. Any flow from the engineering industry to full-time technical college courses is included in the figures for the flow to industry.

Table 6. The Flow into Engineering in Great Britain

The figures are approximate percentages of all the boys in an age group comprising approximately 313 000 boys

Entry at 18 or over			
From universities ..	0·7	POSSIBLE DIVISION INTO TYPES OF TECHNICALLY TRAINED MAN	
From full-time courses at technical colleges ..	0·35		
From schools	0·25		
Entry under 18			
Obtaining degrees, H.N. Diplomas or Certificates, etc., not included above	1·65	**Technologists** ..	2·0
		Technicians	
Total attaining H.N. standard or above ..	2·95	With H.N. Certificate	0·95
O.N. Certificates only ..	1·30	With O.N. Certificate	1·30
Unsuccessfully attempting O.N.C. courses ..	4·75	With some technicians' certificate	3·75
	9·0		6·0
Other craft apprentices ..	7·6	**Craftsmen**	8·6
Total (technically trained men)	16·6		16·6
Clerks (under 18)	1·4		
Others (under 18)	9·8		
Total (all men) ..	27·8		

O.N.: Ordinary National. H.N.: Higher National.

Summary of the Intake into Engineering

Approximately 1·3% of all boys in an age group take up engineering at about 18 or over, as shown in Table 5, and 15·3% take it up as apprentices under 18, as shown in Table 4; this makes a total of 16·6%, or some 52 000 per annum, including graduate and student apprentices. In addition 1·4% enter the engineering industry as clerks and 9·8% as 'others' (excluding any who may enter these categories over 18). Thus the grand total of all boys entering the engineering industry or colleges is about 27·8% of all boys in an age group or some 87 500 boys per annum. This is less than the 30% of boys under 18 shown in Table 1 or the 29·4% of boys entering engineering under 18 shown in Table 2, for only about one-eighth of boys still at school or college over 18 years of age take up engineering as a career.

Table 6 sets out the estimated present flow into engineering by categories of attainment. Of the apprentices entering engineering under 18 about 1·65% eventually obtain degrees, Higher National Diplomas or Certificates, or equivalents, making, with the 1·3% entering over 18, a total of 2·95% attaining this standard. About 1·3% obtain the Ordinary National Certificate only and some 4·75% unsuccessfully attempt first-, second- or third-year Ordinary National Certificate courses. It is probable that less than 4% are at present obtaining City and Guilds intermediate certificates, and this figure will include some of the students who at first make an attempt at Ordinary National Certificate courses. Possibly only some 3·75% out of the 4·75% unsuccessful in Ordinary National Certificate courses would be successful at courses designed for technicians. Very few of the remaining craft apprentices of the intake as it is at present would be successful in technicians' courses, because of apathy and extreme weakness in elementary English and mathematics.

The figures on the right of Table 6 show a possible proportional division into technologists, technicians, and craftsmen. These figures are for the whole engineering industry. As some sections employ a proportion of technologists that is smaller than average, other sections, such as parts of the electrical industry, have higher proportions. The picture is also misleading because considerable numbers of engineering graduates and Higher National Certificate holders proceed to the Civil Service, Atomic Energy Commission, nationalized industries, teaching, and non-engineering industries; the figures for engineering apprentices will not include all those employed in, e.g., the mining and transport industries. Without investigating the adequacy of the relative number of technicians, an increase in technologists to, say, 2·5% would necessitate an increase in technicians to 7·5% to maintain the ratio of one to three. Assuming that half the increase in technologists can be obtained by attracting more boys from those hitherto taking arts subjects in sixth forms, 0·25% would have to come by up-grading those now grouped as technicians, so that 1·75% at present grouped as craftsmen would have to be up-graded to technicians. This would be exceedingly difficult with the present quality of intake of the craft apprentices.

Supply from Schools

The importance of the modern-school stream is shown by Table 4. One third of this stream enter all kinds of employment as apprentices and clerks and three-fifths of engineering apprentices entering under 18 come from it. An appreciable number from this stream reach Ordinary or Higher National Certificate level. However, allowing for the probability that

some of those brighter boys are also included under the 'others' of 'other careers' and for the possibility of some of them entering engineering, the intake of engineering apprentices will include some of the leavers from secondary modern schools who are below average in scholastic ability. Hence it is essential that all boys have as good a grounding as possible in the 'three R's' as well as in science and general subjects if reasonable progress is to be made in technician and craft courses in technical colleges.

Some 7·3% of the intake of engineering apprentices come from the grammar and technical schools. The figure for grammar schools alone is possibly less than 3%, including those taking engineering at universities. Thus, less than one-eighth of the grammar-school stream appears to enter industry as any kind of engineering apprentice.

Table 7 gives the G.C.E. results for the critical subjects for 1953. (The available figures for 1954 do not include all the examining bodies.) The passes in Ordinary mathematics include many older boys and adults, and allowing for the boys from technical schools and possibly a few from the modern schools who obtained passes, the figure for grammar-school boys passing this examination in their stride might be as low as 35000. This is approximately half the grammar-school stream for England and Wales. Of these about 10000 pass in Advanced mathematics with or without mechanics. Most of the remaining 25000 take up other careers, and perhaps only 3000 with G.C.E. Ordinary mathematics enter engineering. Also a considerable number of the students passing in Advanced mathematics do not follow engineering careers.

Table 7. General Certificate of Education for Boys: Summer 1953

	Number		Percentage passed
	Entered	Passed	
	$\times 10^3$	$\times 10^3$	
Ordinary English language	85·7	51·6	60·3
Ordinary mathematics	74·0	45·3	61·2
Ordinary additional mathematics ..	5·1	3·7	71·9
Advanced mathematics	12·1	8·2	67·5
Advanced mathematics and mechanics	3·5	2·2	62·2

The indications are that until the effect of the birth-rate bulge is felt there is not much likelihood of any marked increase in the number of G.C.E. Ordinary-level passes without an improvement in the attitude to study. Should it be possible to obtain the increase in passes in the Advanced subjects necessary to fill the increased university places shortly to be available for technology and science, this must cream off some of the National Certificate entry. Yet for a healthy 'team' for industrial progress the ratio of high-grade technicians to technologists should be increased rather than diminished. The successful outcome of the engineering effort in the last war was made possible in no small measure by the available National Certificate holders.

Conclusion

The manpower figures emphasize both the large part played already by the whole engineering industry in the national economy, and that the nation should make every effort to ensure that the development necessary is not hampered by lack of adequate men of the right quality. It will be difficult to attain the requisite increase in technologists. Moreover to increase the number of technicians will need drastic measures including greater incentives. Both problems demand a realization of the importance of mathematics at all levels. It should not be necessary to teach an apprentice craftsman the simple arithmetic which he ought to have learnt in the infant and junior schools. A sense of responsibility in the boy and his parents is often completely lacking. Is it possible that too much is being done for the child? Are there too many diversions at a time when the young child has a thirst for knowledge and should be concentrating on the 'three R's'? An improvement in the quality of the output from all schools would permit an improved supply of technically trained men.

Secondary technical schools are continuing to supply nearly half of the technicians and are producing increasingly more technologists. To provide additional technologists and technicians, these schools should be developed in preference to grammar schools. Most of the engineering apprentices from the grammar schools who do not obtain National Certificates might well have been successful if they had come through the technical stream.

Any improvement in the output from schools due to a diversion of more of the better boys to engineering, an improvement in the attitude to study, or the effect of the birth-rate bulge can hardly have any real effect on the supply of trained men for a decade. Thus the immediate task is the production of as highly trained men as possible out of those available and the efficient use of them when they are trained. Attention must be given to up-grading, and to avoid keeping promising boys and men on work below their capabilities. As a matter of urgency there should be more pre-apprenticeship and block-release schemes for young entrants; much more generous part-time day release, for many boys till they are over 21 years old, and extending to two days whenever justified; and possibly short as well as long sandwich courses. To obtain the maximum up-grading this country cannot afford to follow the example of some of her competitors, who, not being so highly industrialized, have much larger pools from which to draw, and have virtually a closed engineering profession. At the lower level, even 'shop boys' should be watched for possible up-grading with the same care as apprentices.

Another important aspect is that nearly one-sixth of the boys, including apprentices, who enter engineering are employed by small firms having a total of 10–99 employees; and almost one-half by firms with 10–499 employees. There must also be many boys employed in garages, small electrical contracting and radio businesses and other concerns with less than 10 employees. Special attention should be given to the training and up-grading of the promising boys amongst these. There are three main difficulties: the firm may be so small that it cannot give a comprehensive practical training; the firm may not be able to afford to pay towards the expense of sending a boy on a sandwich course; and the firm may not be able to offer a highly trained man a suitable career and so will be loath to release a capable man for training which will result in losing him.

The public should realize that engineering must continue to be the backbone of this country and of civilization itself. The ultimate task of the engineer will be the adequate provision of food, water, energy and materials on which the future of mankind will depend. Engineering is the most essential and perhaps the most noble calling, and it is imperative that we all play our part in encouraging young entrants and their progress.

THE FIFTH WORLD POWER CONFERENCE

Two thousand engineers and scientists, and about one thousand 'accompanying persons', from 53 countries ranging from Pakistan to Peru converged on Vienna on the 16th and 17th June, to attend the Fifth World Power Conference during the following week.

Great Britain was well represented among the officials of the Conference with Sir Harold Hartley as its President, and Sir Vincent de Ferranti as President of the International Executive Committee. A strong delegation of nearly 250, together with some 150 ladies, attended from this country, in keeping with the important contribution which Great Britain has made, and is still making, to the energy resources of the world. More than one-third of the British delegates were electrical engineers. Official delegates representing other international organizations such as U.N.E.S.C.O., O.E.E.C., C.I.G.R.É., I.E.C. and U.N.I.P.E.D.E.,* also attended the Conference.

The opening ceremony was held on the 17th June in the recently rebuilt State Opera House. The rich internal decoration of the magnificent auditorium, and the flags of all the member countries draped above the stage, formed a colourful spectacle. The proceedings started with the 'Meistersinger' overture; this was followed by an address of welcome by Franz Holzinger, the Chairman of the Austrian National Committee, the Presidential Address by Sir Harold Hartley (some extracts from which appear below), a long lecture in German by Professor Schrödinger, Mozart's 'Haffner' symphony, and further speeches by Chairmen of National Committees. Finally Dr. Theodor Körner, the President of the Austrian Federal Republic, addressed the assembly and declared the Conference open.

The technical sessions started on Monday morning. More than 270 reports were presented, covering a very wide field; hydro-power, coal, lignite, peat, gas, oil, nuclear fuels, and other sources of energy such as solar and geothermal energy. Energy-conserving and energy-converting devices such as heat pumps and fuel cells were also discussed.

The papers and discussions on thermal power plants illustrated the trend towards larger and larger machines and the persistent struggle to increase maximum steam temperature and obtain greater thermal efficiency. Some 200 MW machines are in service in the United States and a 340 MW machine is under construction. Steam temperatures up to 1150° F are now practicable, and experimental plants have been operated at 1250° F. With such temperatures (and the associated high pressures of up to 4500 lb/inch^2), and cycle refinements such as reheating and many stages of feed-water heating, thermal efficiencies of over 40% may be attained.

The technical high-light of the Conference, especially in the eyes of the Austrians, was 'Der Tag der Atomenergie', and the British effort to implement, or possibly to expand, the White Paper programme for 2000 MW of nuclear plant by 1965 will be watched with a great deal of interest in many countries.

Concerning other sources of energy, wind power received scant attention but there was evidence of considerable interest in solar energy. Attention was drawn to the Association for Applied Solar Energy, which has been formed to facilitate international co-operation, and which organized, in conjunction with the Stanford Research Institute, the World Symposium on Solar Energy held at Phoenix, Arizona, in 1955. Research is in progress on the decomposition of water into hydrogen and oxygen by sunlight with the help of photocatalysts. This might lead to an economic method of producing pure hydrogen and oxygen, and these gases could be used in fuel cells to generate electricity.

A Conference newspaper was published every day giving a report of the previous day's discussions, together with the programme for the day and the list of speakers who had indicated their intention to speak in the discussion. The seven issues of this paper thus give a useful summary of the whole proceedings. In addition each delegate was presented with *Power Today*, a four-volume publication giving a survey of the energy economy of the member countries; this will serve as a useful book of reference for some years to come.

Although the amount of technical information made available was immense, an important aspect of the Conference was the opportunity it provided for renewing old and making new friendships. Furthermore the national importance of such a Conference, at which the less highly industrialized countries are quietly assessing the performance and capabilities of the major exporting countries, can hardly be over-emphasized.

A full programme of technical visits to hydro-electric and thermal stations and excursions to places of interest, such as the Vienna Woods, River Kamp Valley, Dürnstein (where Richard I was imprisoned), baroque palaces and monasteries, and of course the Danube, was also arranged. These were memorable occasions and the warmest thanks are due to our Austrian hosts who did so much to ensure our comfort and enjoyment.

Finally on Friday night a concert of Viennese music was given in the Konzerthaus, and on Saturday morning the closing ceremony took place with Sir Vincent de Ferranti in the chair, when Sir Harold Hartley handed over the office of President to Franz Holzinger.

Thus ended a week in which the city of 'wine, women and song' became the city of 'papers, discussions and speeches'—at least in the daytime. But in the evening and the early hours of the morning, under the influence of congenial company, Strauss music, and Wachauer wine, we discovered the meaning of Austrian *Gemütlichkeit*.

J. S. F.

* Union Internationale des Producteurs et Distributeurs d'Énergie Électrique.

Some Extracts from the Presidential Address of Sir Harold Hartley to the Conference

'Six years have gone by since we last met to take stock of the world energy situation at the Plenary Meeting in London and in those years much has happened. We meet at a time when there is a growing awareness of the vital part that energy has to play in our modern civilization. We are living in a century which has been marked by an unprecedented advance in man's understanding of nature. . . . At the same time the world's needs and the world's desires are increasing even faster. Modern communications, thanks to energy, have brought the world closer together. We are living in an age of rapid economic expansion, more rapid in industry alas, than in agriculture, for food is the world's greatest need to-day with the perilous increase in world population. A reminder to us of the dangers that may come from an unbalanced use of man's new power to alter his environment.

'And with these new developments have come new hopes and outlooks. They have made the menace of war so great as to render it almost unthinkable. They have made possible new levels of productivity, higher standards of living, greater comfort, better health and more leisure. But they have faced mankind with the fact that the natural resources of the world are not unlimited and that he may no longer continue to squander them. Our closer knowledge of Nature's erratic distribution of her gifts among the countries of the world has brought home to us the inescapable community of interest of nations. In this modern world, energy, directly or indirectly, is playing a vital part and often it may prove to be the limiting factor in development. There are many others—water, fertile soil, raw materials, manpower and skill, and capital investment—but in all of them energy is an essential factor. . . . The discovery of the possibility of harnessing nuclear energy has come at a most timely moment. The nuclear energy available in uranium and thorium has multiplied the energy resources of the world many times. It will in time make ample supplies of energy available at places where the cost of transport of traditional fuels might be prohibitive.

'A year ago at Geneva the cloak of secrecy was lifted and much of the knowledge, acquired so swiftly by the greatest concentration of scientific and engineering effort on a single project in the world's history, was released for peaceful use. And now with the experience we are sharing of the design and construction of nuclear reactors, we can see the position in better perspective and estimate the probable time scale of nuclear development. With man's proneness to wishful thinking, his easy escape from anxiety, there is a widespread misconception that nuclear power has solved all our energy problems for good and all. Nothing could be more misleading in the public mind. Nuclear power is still in an early stage of experimental development. No one can predict with certainty what form it ultimately may take. There are still many problems to be solved. The construction of a reactor calls for new standards of accuracy and reliability of engineering. Much has still to be learnt about the behaviour of materials under prolonged and intensive irradiation. The papers we shall discuss later throw much fresh light on all this.'

'The pattern of the energy economy in different countries will differ widely according to their needs and resources. With the heavy and long-term investment that is characteristic of the energy industries it is essential for each country to foresee what that pattern is likely to be. For that reason these periodic surveys of the energy economy of each member country that are presented at each of our Plenary Meetings are of special value. Equally the importance of forecasting energy demands and supplies throws an increasing emphasis on energy statistics, the future of which we are to discuss at this meeting. And here the World Power Conference can claim some foresight, as our Statistical Year Book has been a pioneer effort in this field, made possible by the co-operation of all our National Committees.

'The years since 1950 have been a time of rapid progress and we are specially grateful to our Austrian colleagues for their General Reports, which provide such invaluable summaries of the progress made in each of the fields which we are to discuss.'

'There are many specialist institutions on an international basis dealing with these problems in their own particular sector of the energy field. Our founder, Daniel Nicol Dunlop, had the vision more than 30 years ago to foresee the need for a forum where the representatives of all those sectors could meet for the discussion of problems of mutual interest in order that the energy policies of the future might be formulated on the broadest front.'

'As I have said before, food is the most urgent need of the world to-day, and I would ask you to consider whether we are devoting enough thought to the place of power in agriculture as compared with the emphasis we place on industry, and whether the confidence of the less developed countries in the benefits of industrialization may not be deflecting too much of their effort away from agriculture. Mechanization, irrigation, rural electrification and transport are such vital factors in the future of food supply. I am so glad to see that the Yugoslav National Committee, in their interesting programme for next year's Sectional Meeting, have paid so much attention to the place of energy in rural life.

'We are apt to forget that the energy content of the foodstuffs on which all life depends is as much as a quarter of the energy content of the fossil fuels we use to-day. We think of the intricacies of a nuclear power station but they are as nothing compared with the mysteries of nature's power station in the human body,

* The complete text of Sir Harold Hartley's Address will be published in the Transactions of the Fifth World Power Conference.

in which she evades her own laws of thermodynamics by converting chemical energy into mechanical work at constant temperature.'

'In this rapidly changing world our World Power Conference must not be content to record past achievements except as a pointer to the future. Its value will depend, as the introduction to the Vienna Programme so rightly insists, on forecasting the energy problems of the future and the means of their solution. One of the dangers of this complex civilization of ours with its ever growing needs is that we might be caught unawares.'

CORRESPONDENCE

WHAT IS PERMEABILITY?

From Professor R. O. KAPP, B.SC.(ENG.), MEMBER

Professor Cullwick's proposals in the July issue are an attempt to reconcile the conflicting views of those who wish to retain the two C.G.S. systems with those who wish to replace both by the single M.K.S. system. In order to do this, Professor Cullwick is proposing a change of symbols such as will enable one to assign unit value both to the permeability and the permittivity of free space, while at the same time adopting M.K.S. units.

The table given here will help with consideration of the proposal.

	Now in use	Proposed by Professor Cullwick
Symbol for the permittivity of free space ..	ϵ_0	ϵ_0
Value of the permittivity of free space	$8{\cdot}85 \times 10^{-12}$ F/m	Unity (dimensionless)
Symbol for relative permittivity	ϵ/ϵ_0	κ
Symbol for absolute permittivity	ϵ	ϵ
Symbol for the permeability of free space ..	μ_0	η_0
Value of the permeability of free space	$4\pi \times 10^{-7}$ H/m	Unity (dimensionless)
Symbol for relative permeability	μ/μ_0	μ
Symbol for absolute permeability	μ	η

I should like to offer a few comments on Professor Cullwick's letter.

(i) Professor Cullwick's equation 1 takes the form

$$\mu = 1 + 4\pi K \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a)$$

According to B.S. 205, No. 1258, the same equation would be

$$\mu = \mu_0 + 4\pi K \quad . \quad . \quad . \quad . \quad . \quad (1b)$$

Equation 1*b* is more truly algebraic than equation 1*a*, for it holds good whatever numerical value is assigned to μ_0. However, there is a prevalent misconception that the '1' in equation 1*a* is the result of experiment and observation. This is what has led to a great deal of trouble. The truth is of course, that one can verify equation 1*b* by an experiment and can subsequently convert it into equation 1*a* by the arbitrary choice of putting μ_0 equal to 1. No experiment can determine what unit value is to be assigned to any quantity.

(ii) To make the cavity definition complete one has to add that the long and narrow cylindrical cavity contains a substance that has unit permeability. The ratio of the forces on unit pole then becomes B/H, when B and H are expressed in a suitable system of units. If the cylindrical cavity contains air, the force on unit pole in it is H in C.G.S. units but not in M.K.S. ones. Again, the experiment does not decide which units are in the experimenter's mind.

Another misapprehension has grown around the cavity experiment. This is removed when the expressions are generalized in the way they must be for a proper scientific statement. Let the permeabilities of the iron and the substance in the cavity be respectively μ_1 and μ_2. The forces on unit pole are then in the ratio μ_1/μ_2. This proves only that for this experiment a ratio of permeabilities is equal to a ratio of forces. It does not prove that any particular value of permeability is a ratio. And yet there are those who have gone even further. From the experimental fact that $\mu_1/\mu_2 = F_1/F_2$ they have drawn the two conclusions, first that μ is a ratio and dimensionless, and secondly that μ_0 has the numerical value 1.

(iii) Professor Cullwick's objection to the expression 'permeability of free space' has some philosophical justification. For it is at least arguable that free space has no properties. It would therefore be better to speak of the permeability that is measured when a magnetic field occurs in free space, and the permittivity that is measured when an electric field occurs in free space. One would then go on to speak of the velocity of light that is measured when both a magnetic field and an electric field occur in free space. However, to speak like that is cumbersome. The expression 'permeability of free space' must be looked upon as a kind of shorthand. I think it is pedantic to deny oneself its use.

(iv) The objection raised by Professor Cullwick to the adoption of a macroscopic concept, such as flux, for a phenomenon that can be attributed to microscopic events, does not seem to be relevant. It is true that a flux could be expressed by an equation such as equation 4 in Professor Cullwick's letter, but that will never be done in practice. An analogous case is that of temperature, which can also be attributed in molecular theory to microscopic events, but no one would propose to eliminate the concept of temperature or its letter symbol.

Professor Kapp is with Kennedy and Donkin.

AUTOMATIC COMPONENT ASSEMBLY FOR PRINTED CIRCUITS

British manufacturers of radio and electronic apparatus have now begun to install equipment for the automatic assembly of circuit components, where, as in domestic sound and television receiver production, the output of a particular piece of apparatus justifies a change from manual assembly. Methods of automatic assembly make use of printed circuits to provide the main connections in an electronic circuit, and there is now growing interest in Britain in the application of printed circuits to production of electronic equipment, as evidenced by the recent Radio Show at Earls Court. One method of automatic assembly is described here by Mr. McKee, who is with the firm manufacturing the equipment in Great Britain. The system was initially developed in the United States and is at present being further developed both in the United States and this country concurrently. It should be noted that in British manufacture there is no intention at present of printing components in automatic production; standard electronic components are used in the system outlined in this article.

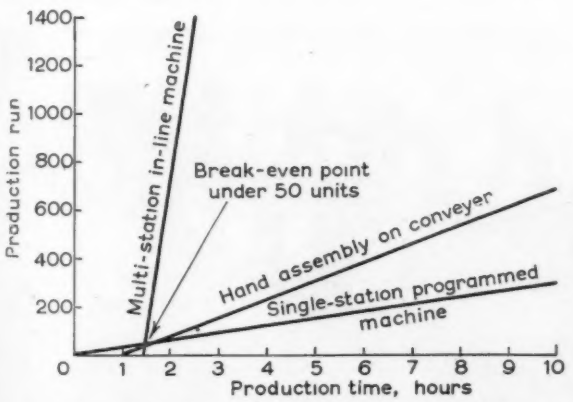
By K. M. McKEE, B.SC., ASSOCIATE MEMBER

THE idea of automatically manufacturing electronic-circuit equipment is by no means new. Since the Second World War several schemes for doing it have been evolved, but probably two of the early schemes came nearer to being used for full-scale quantity production than the others. The first was a British process and the second was the United States Bureau of Standards' Project 'Tinkertoy'. Both systems took what was virtually basic material and converted it into electronic-circuit equipment. It is not at all easy to make the circuit elements in such systems compare in accuracy and performance with the normal types of component, which have been based on many years of design and production experience of established manufacturers. Also, to employ systems of this type economically very long production runs are necessary. With the constant change and modification of electronic circuit techniques, a more flexible method seems to be indicated for commercial production work.

Modern Practice

The development of copper-clad phenolic laminate to a point where circuits formed by etching away the copper can replace conventional wired circuits is relatively recent. The conductors in printed circuits formed in this way are in a single geometrical plane, and unlimited quantities of circuits can be produced to be practically identical. At once the attractive proposition is presented of completely mechanizing the actual printing process, the assembly of standard mass-produced components inserted in the printed circuits, and the subsequent operations of soldering and electrical testing.

To exploit the position, a whole range of new mechanical devices have made their appearance, varying in scope from simple manually operated production aids to the fully automatic flow-through production system. A comparison of the production rates of the three broad groups of assembly methods is shown in Fig. 1, which was compiled for the United States Navy. The graphs illustrate that, for production runs of less than 50 units, an electronically programmed single machine is most suitable, but for higher numbers of units, the automatic in-line (or multi-station) conveyer has by far the highest production potential.



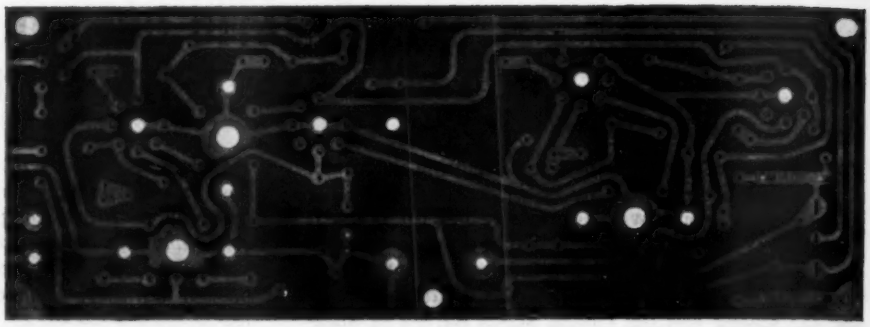
1 *Graphs showing the production rates with three different methods of assembly*

The break-even point is for a production run of under 50.

In-Line Conveyer Design

The fundamental idea behind the automatic in-line conveyer is to break down the intricacies of a complex assembly operation into a series of easy stages, which in turn means a line of comparatively simple and reliable mechanisms. The separate machines operate simultaneously, each inserting a single type of component into the printed-circuit boards as they pass down the line. Although the action of individual machines is quite leisurely, the output rate is astonishingly high; and it is independent of the number of components to be inserted, since the conveyer may be extended to accommodate any desired number of component-inserting machines.

It is essential that the assembly process be made as flexible as possible, and capable of inserting a wide range



2 *The first printed circuit to be assembled automatically in the United Kingdom on a full commercial basis. A 4-valve portable radio receiver seen from the underside, the components when assembled being mounted on the reverse side*

By courtesy of the *Telegraph Condenser Co.* and *E. K. Cole, Ltd.*

of components into a variety of shapes of printed-circuit board. Change-over from one printed-circuit layout to another must be rapid and easy. Other essential points for factory use are: robust construction, relative freedom from stoppages, together with routine operation and maintenance that can be carried out by unskilled staff.

Automatic Assembly Machines

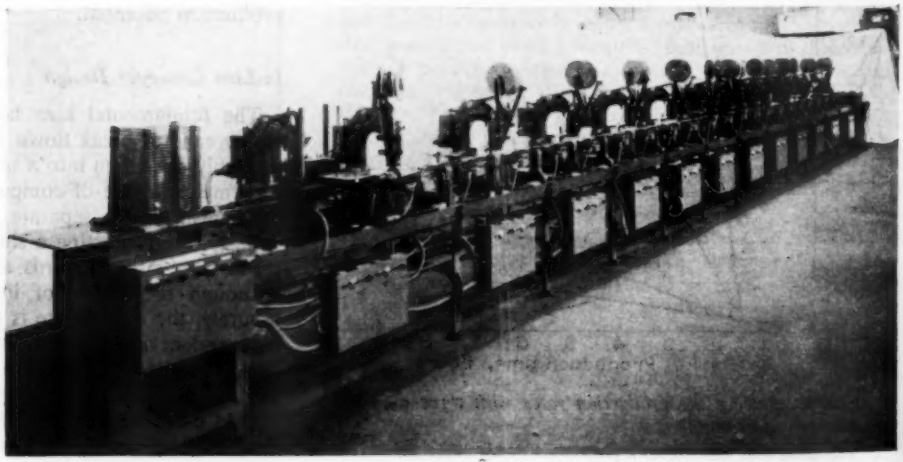
Automatic in-line assembly machinery which has been designed to incorporate these features is being further developed concurrently in this country and in the United States. Several leading U.S. manufacturers have been employing this machinery for two years on large-scale production of circuits for radio and television receivers. The first conveyer in the United Kingdom has recently been installed in the factory of a British manufacturer, who at the time of going to press is applying it to the assembly of the 4-valve portable receiver circuit shown in Fig. 2.

Conveyer Action

The system fundamentally consists of a straight-line conveyer on which are mounted individual component-inserting machines (Fig. 3). The number of machines can be increased to a maximum of 40 with a single conveyer drive motor, while tandem arrangement of two conveyers permits as many as 80 machines in line. At one end, printed-circuit boards are automatically fed in by the board-loading machine (Fig. 4) beneath a ram plate, which presses the board into spring clips mounted on a light metal frame, or pallet, in which the board is transported by the belts of the conveyer down the line.

Owing to an inherent tendency in phenolic laminates to dimensional instability, the use of pallets assists accuracy of location, and offers flexibility in the choice of board shape and size. Two or three special location holes are usually punched out at the corners or edges of the board. One of these must be round, the remainder may be drawn, to allow for expansion or contraction in the laminate, as shown in Fig. 2. The spring-loaded clips hold the board securely down through the holes onto the hardened-steel location pins in the pallet.

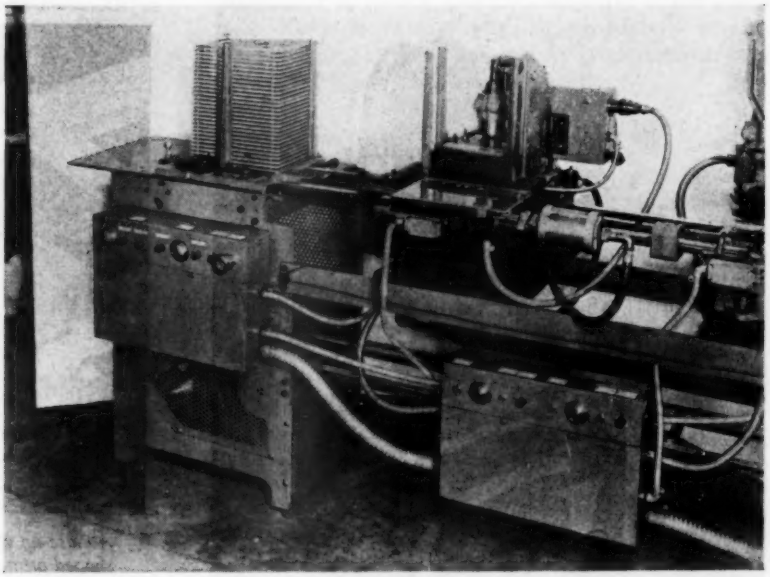
At the other end of the conveyer, a ram plate on the board-unloading machine pushes the board off the pallet from underneath, and fingers on the unloader arms raise the board, which slides off down a shute. Empty pallets are then transported by a return conveyer to the head of the conveyer. It will be seen that the number of pallets required is equal to the number of machines on the conveyer, plus a few extra to maintain circulation and form a reserve in the stack.



3 *A conveyer with fourteen component-inserting, board-loading and unloading machines*

A principle of the conveyer described here is to obtain reciprocating motion by pneumatic cylinders with their associated lever arms, and rotating motion by electric motor drive, while the whole sequence of operations is controlled electrically. On arrival at an individual machine, the pallet trips a microswitch, and when and only when the microswitches of all machines have been actuated, will the pallets be raised from the conveyer belts and locked solidly into position beneath the machine heads. The insertion cycle of every machine is synchronized by electrical timing relays in a master control box mounted at the loading end of the conveyer. Various electrical interlock circuits with indicator pilot lights are incorporated to arrest action in the event of a major stoppage. The control box associated with each machine is fitted with appropriate switches which enable the machine to be operated independently, or switched completely out of circuit.

Each machine is fixed in position on the conveyer by means of a single clamping screw, which allows it to be removed or re-positioned in a matter of minutes. In order to set an inserting head to place a component in any desired position on the board, the head of the unit is rotated about a vertical axis and the machine is adjusted by the clamping screw on its baseplate, the holes in a sample board serving as a setting-up jig. It will be appreciated that punching errors between sets of component holes are of no consequence provided the error is consistent on all boards.



4 *The loading end of the conveyer, showing the board-loading machine with pallet stack and control boxes*

Inserting Machines

Inserting machines may be divided into three main groups:

(i) Axial-lead component machines, e.g. the machines which will insert most types of resistor, many types of capacitor and jumper wires.
(ii) Machines which will handle other types of component, e.g. radial-lead capacitors and valve bases.
(iii) Machines which will automatically place eyelets, tags, and terminals on printed-circuit boards, or, in fact, on any type of board.

Both the second and third groups of machines are still under development in this country and cannot at this stage be described in detail. It is the type of component and the method of feeding it to the insertion head which differentiates these three groups. In the first group the components are belted up by fixing their leads to adhesive tape, and wound onto reels; except for the jumper wires which are produced from a machine that simply cuts off fixed lengths from a normal reel of wire. The components inserted by the second group of machines, owing to their shape, cannot conveniently be belted and so have to be fed from hoppers or magazines. The small metal parts in the third group will be either raceway or, perhaps, strip fed, and the machines are required to exert considerably more pressure to set the parts firmly into the board.

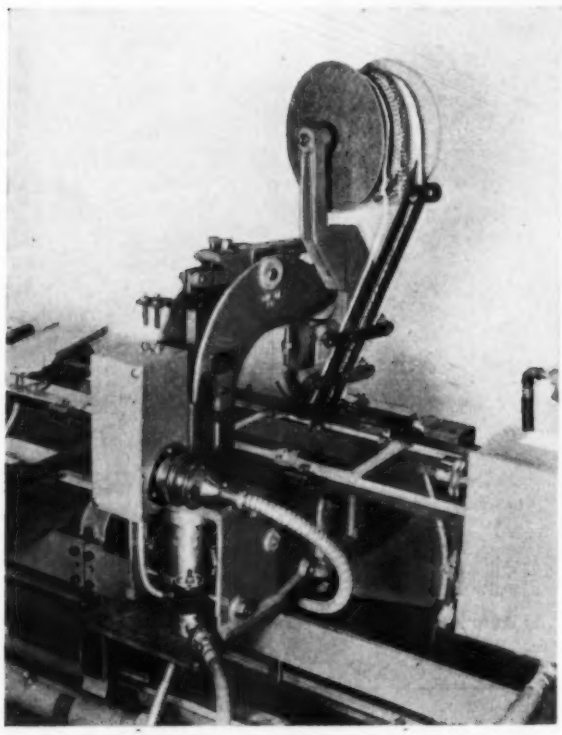
Axial-lead Component Machines

It is hoped that component manufacturers in the United Kingdom will be able, before long, to offer their standard ranges of axial-lead components in belted form. In all manufacturing processes, it is now generally recognized that, for efficient handling, leads should be kept reasonably straight. Belting machines, which straighten out slight bends and kinks in the leads, space components, and belt them up on reels, are not elaborate or particularly expensive; and they are to be made available for use by both component and set makers.

The cost of belting is less than a penny per 50 components and even less if non-adhesive, instead of adhesive, paper tape is used as a backing. A reel will hold up to standard 2 500 ½-watt resistors or other axial-lead components of similar dimensions. Savings are possible in packaging costs, and some equipment manufacturers have expressed their preference for purchasing belted

components for manual assembly work to avoid the nuisance and delays caused by tangled leads.

When a machine is in operation, components, on leaving the reel, are drawn down the slide into the insertion head (Fig. 5). Here their leads are engaged on either side of the component body by accurately spaced grooves round the circumference of two feed wheels.

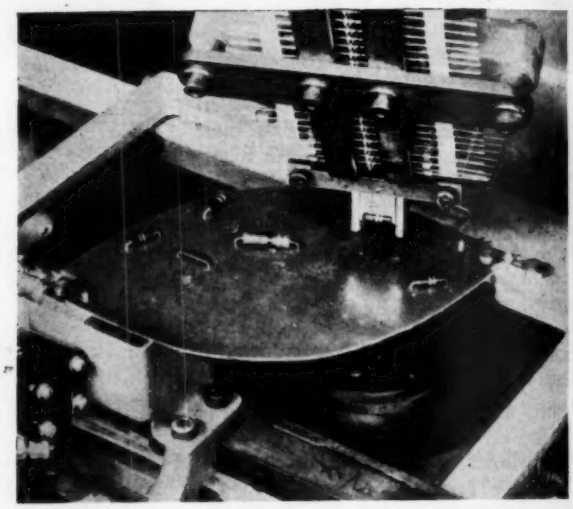


5 *An axial-lead component machine inserting a component into a printed-circuit board on the conveyer*

Sufficient length of components is stored in the raceway to allow reels to be replaced when expended without interfering with continuity of production.

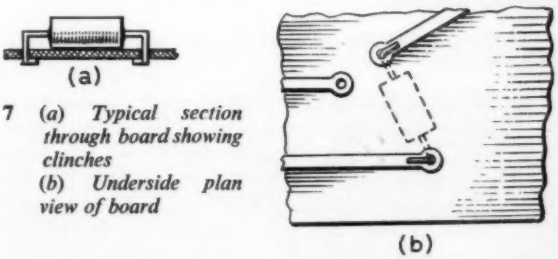
On compressed air being released into the main cylinder situated vertically in the frame, lever arms move the tools in the head down towards the board and pallet. At the same time shear bars cut off excess length from the leads, which are then formed, and carried down by a driver through pre-punched holes in the board, as illustrated in Fig. 6. The main cylinder through another linkage system raises vertical push-type anvils, which clinch over the leads in any preset direction from underneath, so that the ends of the clinched wires lie along the printed conductors (see Fig. 7). The experience of many millions of insertions in the United States has shown that wires cut and clinched in this manner greatly assist in forming reliable dip-soldered connections to the printed conductors. It will be noted that at every stage the component is held by its leads, thus eliminating the possibility of damage to the component body.

The lead-hole centre spacing is standardized for any one size of component; though within the dimensional limitations of the component and inserting head, tools may be made to accommodate other spacings. Inserting machines are designed to cover three ranges of size of component. The first handles components up to $\frac{3}{4}$-inch lead-hole spacing, the second up to $1\frac{5}{16}$-inch spacing and



6 *A close-up view of a resistor about to be placed in an oval-shaped printed-circuit board*

the third is being developed for components with bodies up to $2\frac{1}{2}$ inches in length and 1 inch in diameter. Another machine in this category is the jumper-wire machine, which is of particular interest to circuit designers in solving layout problems. This will cut to length, place and clinch a plain or coated copper wire between any



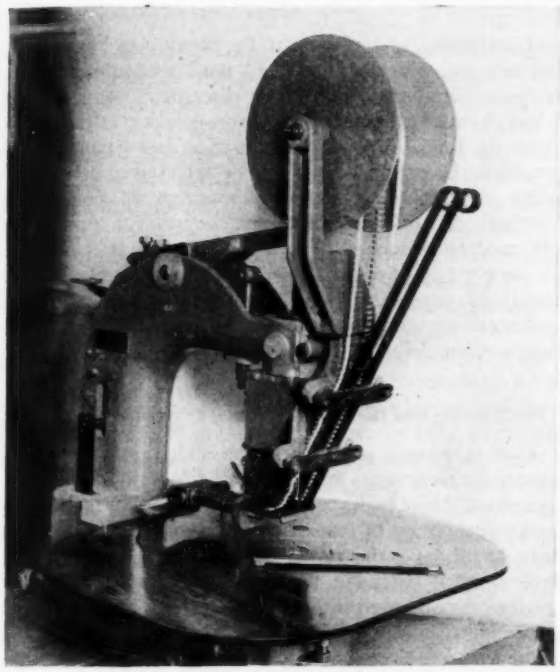
7 (*a*) *Typical section through board showing clinches*
(*b*) *Underside plan view of board*

two holes up to $1\frac{5}{16}$ inches apart. The wire when soldered on the reverse side of the board forms a useful bridge connection between two printed conductors.

Semi-Automatic Production

Where production runs are short and normally limited to 50 printed-circuit boards or less, the insertion

machines, with minor modifications to the air valve control for foot operation, may be employed as separate bench machines; an example is shown in Fig. 8. For this application, an optical location device provides a valuable aid to accurate and rapid insertion. Two narrow beams of light are reflected down onto the surface of the board, which is quickly manoeuvred round until the points of light disappear into the appropriate set of holes; the foot pedal is then depressed and the component is automatically inserted and clinched. Other



8 *A bench-type component-inserting machine, with light location attachment for placing components in a printed-circuit board without a conveyer*

methods of registration, depending on special location holes in the board, or on the edges being accurately cut relative to the component holes may be used in conjunction with magnetic stops on the metal table beneath the inserting head.

Figures obtained by British manufacturers indicate that four seconds are needed to insert one component, and thirty-two seconds to change the reel to another component of different value but of the same dimensions. Machines performing in this time the four operations of cutting, forming, inserting and clinching show marked advantage over manual performance of the same work.

Other Component-Inserting Machines

More advanced machines are in course of development for placing up to 75% of all components used to-day by the electronic industry. These include machines for flat and cylindrical capacitors, disc capacitors, and a wide variety of printed-circuit valve bases.

Eyelets, tags and special terminals may be set by machines very similar in principle to those already installed in many factories as manual bench machines.

Small metal pressings like these are often of value in terminating interconnecting leads between printed-circuit boards and larger assemblies. It has been suggested that it would be possible during intervals in production to employ usefully a conveyer with a line of such machines in making up tag boards and terminal strips which are daily required in large numbers with current types of electronic equipment.

The Advantages of Automatic Assembly

Most manufacturers when considering a new production method will look for significant saving in terms of reduced manufacturing costs. Single conveyers under normal factory conditions have been proved capable of maintaining an output of 9600 assembled boards each 8-hour working day with a machine insertion reliability of better than 99·8%. While it is realized that this performance is in excess of the present requirements of all but the largest British manufacturers, such a rate does not have to be continuously maintained for economic or efficient working. It is estimated that the average-size manufacturer of radio and television receivers in the United Kingdom should pay off the initial cost of a conveyer against the cost of existing methods in less than two years, operating only a few days per week at the full production rate. This estimate is based on the fact that each radio receiver will contain one or more printed-circuit boards, and each television receiver three to five. In addition to domestic receivers, many other types of electronic equipment lend themselves to automatic assembly, particularly the sub-units that go to make up computers and electronic telephone exchanges, which are in future likely to be needed in increasing numbers.

The following are typical examples of indirect advantages of automatic assembly that may be expected:

Elimination of unproductive training periods.
Reduction of human error in assembly.
Reduction of setting-up costs and lost time when changing the product.
Increased uniformity and reliability of the product.
Elimination of the necessity of employing marginal labour.

In general, the introduction of automatic assembly is an important and integral part of the evolution in manufacturing techniques that is now taking place in the electronic industry. The immediate objective is a completely automatic flow-through production system, beginning with the mechanized processing of printed circuits, and followed by automatic assembly, mechanized dip-soldering and automatic electrical testing.

Acknowledgment

The assembly machines described in this article are identified in both the United States and Great Britain by the trade mark 'Dynasert'. The author is indebted to the Geo. Tucker Eyelet Co. for permission to publish the article.

SHORT REVIEWS OF PAPERS

On the following pages are some brief articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Telephone Switching

A short review of a Radio and Telecommunication Section paper (No. 1993) entitled 'Time Sharing as a Basis for Electronic Telephone Switching: a Switched-Highways System', by L. R. F. Harris, M.A., Associate Member. The paper was published individually in March 1956, and it will be republished in Part B of the Proceedings.

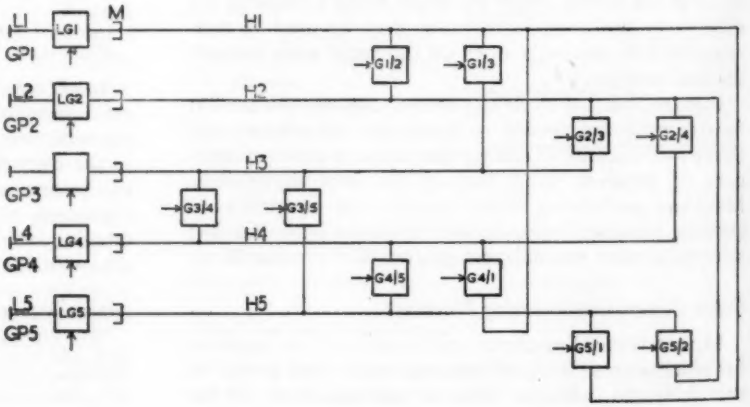
ALTHOUGH THE MANY AUTOMATIC TELEPHONE SYSTEMS developed in the last fifty years differ in many ways, the same basic principles are used in their design. This is not only because they provide almost identical services but because in all systems advantage is taken of the transitory nature of the operations to be performed. Each call lasts a finite time and involves a sequence of operations of which many are required for part but not the whole duration of the call. Telephone engineers have always used this fact to economize in apparatus. If an operation is not required continuously on any circuit or connection, the apparatus performing it can be time shared by a number of circuits or connections, or it can be used to perform a series of operations on a connection.

With electromechanical components, time sharing has been achieved using switching and coding techniques. Switching enables apparatus to be brought in to perform particular operations on a connection and to be held continuously until the operations have been carried out. The apparatus is then released and made available for other connections. Thus speech apparatus (e.g. trunks and switches) is brought in to provide a connection between two lines, and is held until the connection is released. Similarly a register or director is connected to a line in order to receive and use designation information from the line. When this information has been used to establish the connection it can be released and used on other calls. Coding enables apparatus to perform a number of different functions depending upon the information presented to it. Thus it is common practice to use a group of relays to perform a number of different functions depending upon the combinations of relays operated. By coding, each relay is used for different functions at different times.

Time Sharing and the Introduction of Electronic Techniques

During recent years some possible applications of electronic techniques in automatic telephony have been examined. Their high speed enables the operating, holding and release times of many items of apparatus to be made very small, and the range of application of switching techniques is extended. For example, a single common marker may be used to set up all the calls in a telephone exchange of any size. The increased flexibility of design obtained with electronic apparatus also enables information to be handled in larger blocks and a higher degree of time sharing by coding to be achieved.

High speed also permits the introduction of sampling techniques in telephony, so that apparatus can be used to transmit, receive, store and operate upon information in the form of pulse samples. Apparatus is then time



1 *Switched-highways system: basic trunking*

GP—Group.
L—External line.
LG—Line gates.
H—Group transmit and receive highways.
G—Inter-group gates.
M—Number of external lines in GP1.

shared by using it cyclically with samples relating to different lines, connections or functions in turn. The rate at which a waveform must be sampled without losing information depends upon its rate of change. Thus with present techniques speech-carrying equipment may be time shared over, say, 80 connections, and apparatus handling more slowly moving waveforms (such as dial pulses) may be time shared, and hence made common to very many more.

A Switched-Highways System

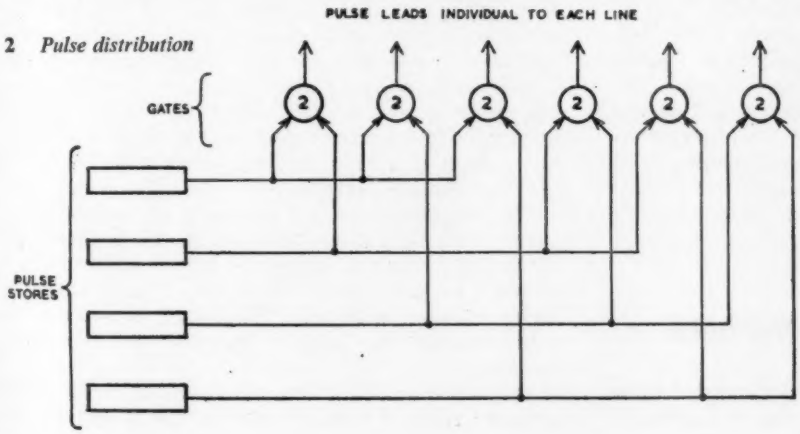
These possibilities are illustrated in an experimental system known as the switched-highways system, which has time sharing as the main basis of its design. In this system the lines are arbitrarily arranged in groups in which each line is connected by gates to highways common to the group, and over which speech samples may be transmitted to and from the lines. Up to 80 cyclically recurring sampling times are available for connections on each of the highways, and these times are synchronized on all highways. As shown in Fig. 1, the highways of each pair of groups are interconnected by gates, and two lines in different groups are connected by allotting them the same sampling times, and by opening the gates interconnecting their highways at these times. Such calls are said to be using a particular *pulse channel*, and any of the 80 pulse channels can be used to connect any pair of lines in different groups provided that it is not already in use on the highways of the two groups. Since each channel can be used for a connection to any line, the number of lines in a group can greatly exceed the number of channels. With 80 channels, a group capacity of between 300 and 1000 lines is possible, depending upon the traffic carried. The pulse channels are time shared by the lines, and the highways and gates are time shared by sampling. Any number of groups of lines may be interconnected in this way and the system is therefore applicable to even the largest exchanges.

Connection between lines in the same group is made by connecting the two lines to different pulse channels which are free on the group's highways, and by suitably interconnecting the channels.

In order to allot any pulse channel to any line, each group of lines is provided with a group of delay-line storage systems. Each line is connected to a unique combination of these stores, and only channels stored in this combination are effective in the line's gates. This is illustrated in Fig. 2, where 4 stores distribute the pulses for 6 lines which are each associated with 2 of the stores. 16 stores could serve 560 lines if each were associated with 3 stores. Similar groups of stores are used to feed the inter-highway gates of each group. The delay-line apparatus is time shared by the pulse channels and by the lines using coding techniques.

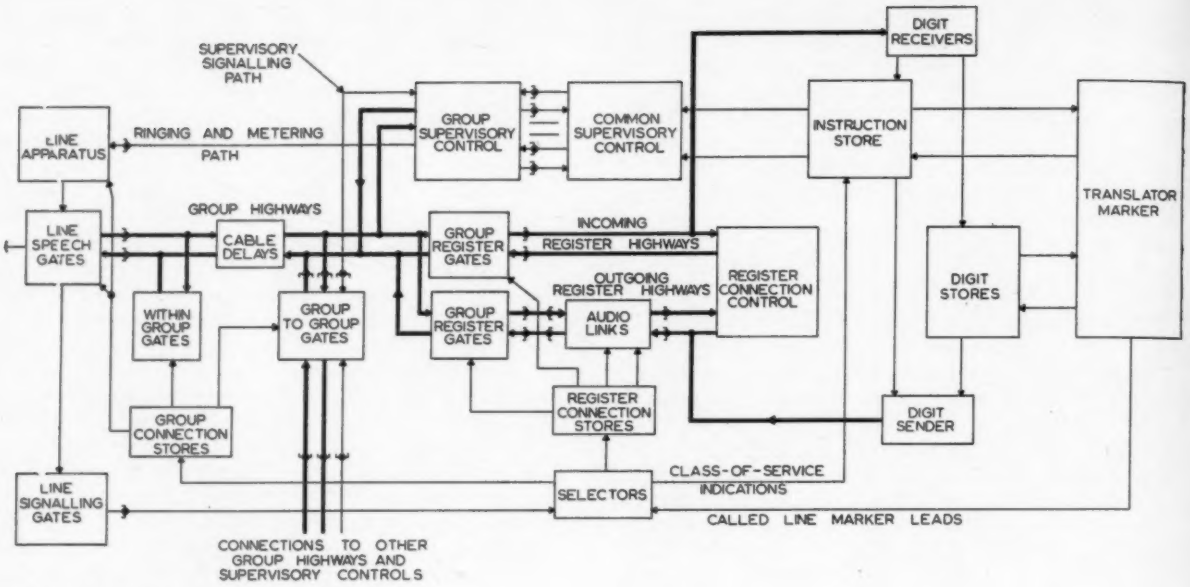
The switched-highways system is a register-marker system, and the highways of each group are connected to incoming and outgoing register highways, which carry incoming and outgoing register traffic respectively. A calling line is connected to the register apparatus using a pulse channel which is free on its group and the incoming register highways. The connection is set up under the control of common selecting apparatus, which sets up all connections by indicating the channel and stores to be used. The selectors also indicate the calling line's class of service. A block diagram of the complete system is shown in Fig. 3.

The pulse channel used for the incoming register connection is used in the register apparatus to transmit, receive, store and operate on all the information relating to the connection. Class-of-service and other instruction information is stored in a group of instruction stores and the designation information is stored in a group of digit stores. When sufficient digits have been received a common translator-marker translates the digits received from the digit store into signals which show the fee and routing instructions. The translator-marker also indicates the suitable outgoing lines to the selectors, which operate to make the connection. If necessary these selectors also set up a connection between the register and the selected outgoing line. In order to send routing digits (stored by using the incoming-register-connection pulse channel over the outgoing register connection using a different channel), an audio-frequency link in the outgoing register highways is used to convert the information from one channel to the other. This outgoing register connection is released together with the register when the complete connection is made.



2 *Pulse distribution*

When the selectors set up the connection between lines, instruction information is transferred from the register to supervisory apparatus which controls the subsequent progress of the call by operating on the pulse channel used for the connection. The supervisory apparatus performs a sequence of operations



3 *Block diagram of the switched-highways system*

(including tone sending, bell ringing, fee registration and connection releasing) depending upon the information so presented to it.

The supervisory and register apparatuses effect their control by means of techniques like those of a computer, in which the information is stored and manipulated using the presence and absence of pulses. These binary elements correspond to the relays and contacts used in the control of electromechanical exchanges, and a high degree of time sharing by coding is achieved. The use of sampling techniques enables the control apparatus to be time shared over many connections. Much of the supervisory control apparatus, for example, can be made common to many groups by allocating it to different groups at different times.

The underlying principle of design is to associate any item of apparatus with any function for as short a time and as infrequently as can be tolerated without loss of reliability or service. The high operating speed and flexibility introduced by electronic components enable this principle to be applied to a very high degree in the switched-highways system. This system is still in the experimental stage, and since many promising components and circuit techniques are still under development it is difficult to estimate the ultimate capital and maintenance costs, but they are expected to be competitive with those of existing systems. 621.395.65

Transistors in Radiation Monitors

A short review of a Measurement and Control Section paper (No. 2049) entitled 'The Application of Transistors to the Trigger, Ratemeter and Power-Supply Circuits of Radiation Monitors', by E. Franklin, Ph.D., Associate Member, and J. B. James. The paper was published in July 1956, in Part B of the Proceedings.

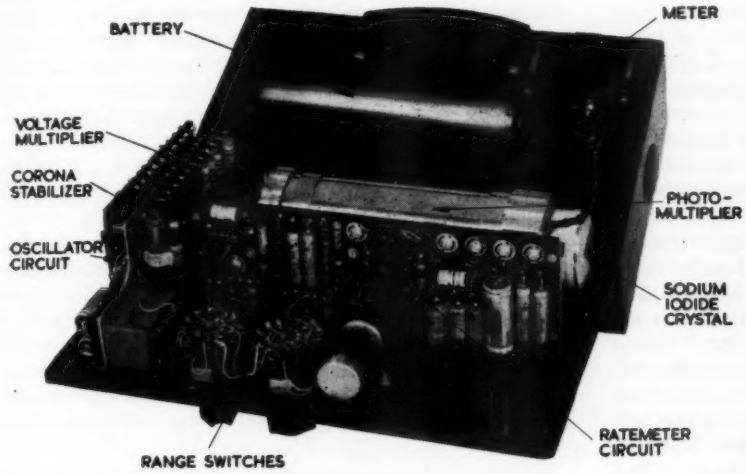
WHEN DESIGNING THE ELECTRONIC CIRCUITS DESCRIBED in the paper, the authors had in mind chiefly the types of radiation monitor used by geological field parties.

There are two main applications for transistors in such instruments—first, the d.c.–a.c. conversion required to produce the high operating voltage for the radiation detector, and, secondly, the amplification of the small radiation-detector signals to a level suitable for operating a meter. High-voltage batteries provide an alternative to the d.c.–a.c. conversion, but these have proved unreliable, particularly in hot climates. It is in any case highly desirable that all batteries used should be of low-voltage flash-light types, which are readily available in all parts of the world. Mechanical vibrators and hot-cathode valve oscillators can be used for the d.c.–a.c. conversion, but transistors score over both of them on power economy and probably also on reliability. The low output frequency, with the correspondingly larger transformers and smoothing components, is a further disadvantage of the mechanical vibrator.

The alternatives to the transistor for amplification purposes are the hot-cathode valve and the cold-cathode valve. The arguments against the former are mentioned above. The latter, while being reliable and having a highly economical power consumption, is unusable in many instruments owing to its rather low operating frequency.

Use of the transistor does not appreciably reduce the size or weight of monitors (except that it reduces the

battery weight for a given operating time) because other components, such as the radiation detector, meter, and range-changing components, are large compared with the transistor or its alternatives.



1 *Scintillation counter*

The principal problems involved in the power-supply circuits are the economical production of a stable high-voltage supply for the radiation detector (2000 volts in the case of the scintillation counter) and stabilization of the low-voltage supply (6 volts) for the amplifier and count-ratemeter circuits. A method is described in which a single corona or glow-discharge stabilizer stabilizes both the high- and low-voltage supplies and also fixes the battery current and the power-supply output current independently of battery voltage. A life of several hundred hours is obtained with a $4\frac{1}{2}$-volt torch battery.

2 *A monitor utilizing Geiger–Müller counters*

The main design difficulties in the ratemeter and amplifier circuits arise from the change of transistor characteristics with temperature. However, it has been found possible to obtain a calibration accuracy of about $\pm 2\%$ over both a temperature range $-40°$ C to $+60°$ C and a battery-voltage range $4\frac{1}{2}$–3 volts.

Fig. 1 shows a typical transistor scintillation counter having four ranges of sensitivity, with arrangements for operating a chart recorder. The radiation detector is a thallium-activated sodium-iodide crystal with an 11-stage photomultiplier. Fig. 2 shows a five-range instrument based on the Geiger–Müller counter, with an internal bank of four halogen-quenched gamma-ray counters and facilities for attaching an external beta-ray probe.

621.387.4 : 621.374.3 : 621.311.6 : 621.314.7

High-Speed Transistor Scalers

A short review of two Radio and Telecommunication Section papers (Nos. 2064 and 2076) entitled (i) 'A Point-Contact Transistor Scaling Circuit with 0·4 microsec Resolution', by G. B. B. Chaplin, M.Sc., Ph.D., Graduate, and (ii) 'A Junction-Transistor Scaling Circuit with 2 microsec Resolution', by G. B. B. Chaplin, M.Sc., Ph.D., Graduate, and A. R. Owens, M.Sc., Graduate. The papers were published individually in March 1956, and they were republished in July 1956, in Part B of the Proceedings.

ONE OF THE MAIN LIMITATIONS TO THE USE OF TRANSISTORS for many applications is their restricted high-frequency response. For instance, of the types at present readily available, point-contact transistors have cut-off frequencies in the range 1–5 Mc/s, and junction transistors in the range 300–1 000 kc/s. When transistors are used in conventional two-state circuits, however, the pulse rates obtained are lower than the above figures by a factor of ten or more. This is due mainly to the effect of the external circuit arrangement. For instance, a conventional cross-coupled binary scaler using junction transistors contains capacitive memories, which demand large charging currents and voltage swings to attain high speeds. However, the use of large currents has a retarding effect upon transistor operation, so that one must accept a substantial reduction in speed with this class of circuit.

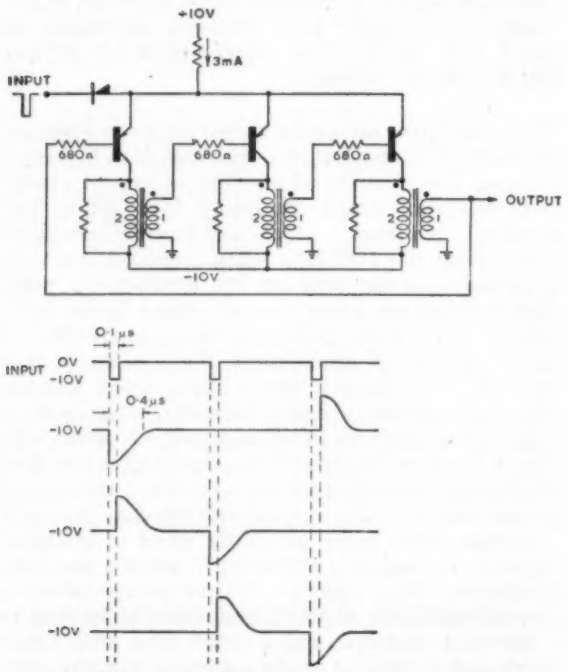
Another factor which affects the speed of transistor circuits is the degree of bottoming to which a transistor is subjected during operation. Carrier storage (which is proportional to the degree of bottoming) takes place in a bottomed transistor, and a certain time must elapse before such a transistor can be restored to its active state.

There are two obvious ways in which the speed of

circuits using transistors may be improved. A circuit technique may be evolved which does not impose the limitations of the conventional capacitive coupling arrangements upon the transistor, and transistor operating conditions may be so arranged that bottoming is greatly reduced or even eliminated.

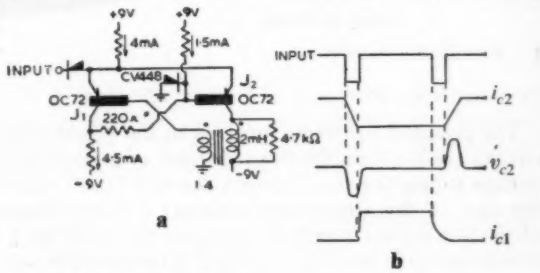
The circuits described in these two papers have been developed along these lines. Since transistors are current-operated devices, it seems logical to use a current-operated circuit element, such as an inductor, as a reactive memory. An inductor may be charged rapidly by applying current to it, and the use of inductors as the reactive elements in transistor circuits provides a means of increasing the operating speed by reducing the charging time. An inductor has also another advantage in that it may form the primary of a transformer. Thus the total current gain required of a circuit may be obtained in a step-down transformer, demanding a current gain of only unity from the transistor. This in turn allows greater freedom in the choice of transistor connections. For example, with junction transistors the use of a common-base circuit, with a current gain of slightly less than one, but with an inherently faster response, becomes possible, resulting in increased operating speeds. The lower current levels which may now be employed, as there are no capacitors to be charged, enable the degree of bottoming to be reduced to advantage.

Fig. 1 illustrates the application of these principles to a point-contact transistor circuit. The emitters are supplied from a common current source, an arrangement which ensures that when one transistor becomes conducting, the base current flowing in the external base resistance reduces the base potential of that transistor (and hence the potential of the emitter line) to below earth potential, so that the other transistors are held cut off. A negative input pulse applied to the emitters through a diode cuts off the current flowing in the collector memory inductance of the conducting transistor; the resulting negative pulse is transformer-coupled to the base of the following transistor which is thus caused to switch on when the input pulse is completed. The conducting state is shifted along the line of transistors by the input pulses, and by connecting n transistors in a closed ring in this way a scale of n may be obtained. The circuit is designed so that at no time during the cycle of operation is any transistor allowed to bottom. The arrangement described in the first paper, based on the above circuit, consists of a scale of ten made up of a scale of two and a scale of five. This circuit has a resolving time of 0·4 microsec.



1 *Scale-of-3 circuit with collector-voltage waveforms*

The second paper describes how similar principles may be employed in the design of junction-transistor scalers. Fig. 2 shows a binary scaler (using audio-frequency junction transistors) which has a resolving time of 2 microsec. The right-hand transistor J_2 cannot bottom during operation, and the left-hand transistor J_1 is allowed to bottom only slightly, in order to minimize carrier storage. A memory is provided by the primary inductance of the transformer in the collector lead of J_2. If the transformer were not present, the negative-going input pulses would always set the circuit so that J_2 was on and J_1 off. The transformer, however, gives out a negative pulse when an input pulse is applied if J_2 has been conducting, owing to the rapid cessation of current in J_2. This negative pulse is applied to the base of J_1 by the transformer secondary, so that J_1 is turned on. The next input pulse restores the previous condition, with J_1 off and J_2 on, and the cycle is then repeated with succeeding input pulses, and binary scaling is achieved. The paper describes how three similar binary stages may be coupled together to give a scale of five, which gives a scale of ten when cascaded with another binary stage. It is interesting to note that a direct valve analogue of this circuit is possible, which retains the advantages of high operating speed and simplicity of circuit arrangement.



2 *Complete binary scaler*
(*a*) Circuit. (*b*) Current and voltage waveforms at the collectors.

By using experimental h.f. junction transistors, the figures quoted in the paper may be much improved upon, the performance then being comparable with, or better than, that of the point-contact scaler. In general the limiting speed is of the same order as the transistor cut-off frequency, and transistors having nominal cut-off frequencies of 2 Mc/s and 10 Mc/s scale reliably at 2 Mc/s and 10 Mc/s respectively. The power dissipation per binary stage is about 50 mW. 621.374.32 : 621.314.7

Transistors in Distance Relays

A short review of a Supply Section paper (No. 2085) entitled 'Power System Protection, with Particular Reference to the Application of Junction Transistors to Distance Relays', by C. Adamson, M.Sc.(Eng.), Associate Member, and L. M. Wedepohl, B.Sc.(Eng.), Graduate. The paper was published in August 1956, in Part A of the Proceedings.

PROTECTIVE RELAYS USING THERMIONIC VALVES, THYRATRONS and cold-cathode tubes have been devised in the past. These have not been met with much favour by power-system engineers, owing to the need for expensive power supplies, and the restricted useful life of the valves. The development of junction transistors, to a point where their life and reliability are claimed to be many times that of thermionic valves, makes it possible to produce protective relays having the advantages of earlier electronic relays, and without the principal disadvantages.

This situation led to the possibility of applying junction transistors to high-speed distance relays. Two relays were devised and tested; these were based on the well-established principle of comparing the difference in phase angle between two voltages derived from the current and voltage of the protected system. One relay used the technique of measuring the instantaneous polarity of one voltage at the instant of positive maximum of the other voltage; this latter instant being defined by a pulse. The second relay made use of the principle of measuring the time interval over which both voltages were instantaneously of the same polarity.

It is shown that, in common with conventional electromechanical relays, transistor relays may be given a variety of characteristics of the type generally used in distance and directional applications. Each of the relays initially developed was arranged to have a mho-characteristic, defined by the equation:

$$Z < Z_R \cos(\theta - \phi)$$

where Z is the modulus and ϕ the angle of the impedance presented to the relay terminals (i.e. the ratio of fault voltage to fault current referred to the relay terminals) and Z_R is the modulus and θ the angle of the nominal relay impedance setting. The choice was made because this type of relay has the advantage of combining in one element the individual characteristics of impedance and directional relays.

Both relays were subjected to a series of static tests in order to verify the validity of the basic theory. Finally they were tested dynamically on a modern protective-gear test bench, which was designed to simulate closely a faulted power system. These tests showed a severe practical limitation on performance which is peculiar to many high-speed relays, namely transient overreach. Since both relays operated on a principle of instantaneous comparison of two voltages, they were excessively sensitive to the presence of d.c. components in their energizing voltages. Maximum transient-overreach factors of the order of 0·5 and 0·7 were recorded, and these made them unsuitable for use in a practical scheme.

A further limitation was the falling off in performance with decreasing fault current due to input bias. This is a basic problem with all distance relays, and is analagous to the effect of friction in electromechanical relays.

Finally the relay which used a pulse technique to obtain the required characteristic was found to be sensitive to the presence of spurious pulses emanating from the test system. For this reason further research work on this type has been discontinued.

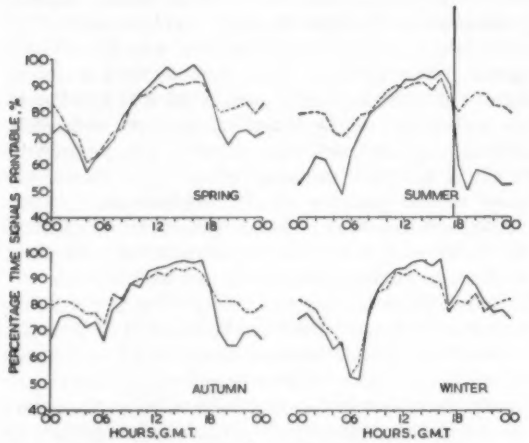
It is concluded that in most respects junction transistors are superior to thermionic valves in protective-relay applications. Test results have indicated that circuit design must be modified in order to overcome some of the limitations. In particular, there is the opportunity of eliminating transient overreach by using a filter or some type of 'push-pull' arrangement. The accuracy of the relay may be extended by using a compensating network. More recent work on these lines has resulted in greatly improved characteristics. 621.316.925.45 : 621.314.7

Asymmetrical Radiotelegraph Performance

A short review of a Radio and Telecommunication Section paper (No. 2118) entitled 'Asymmetry in the Performance of High-Frequency Radiotelegraph Circuits', by A. M. Humby, Member, and C. M. Minnis, M.Sc., F.Inst.P., Associate Member. The paper was published in July 1956, in Part B of the Proceedings.

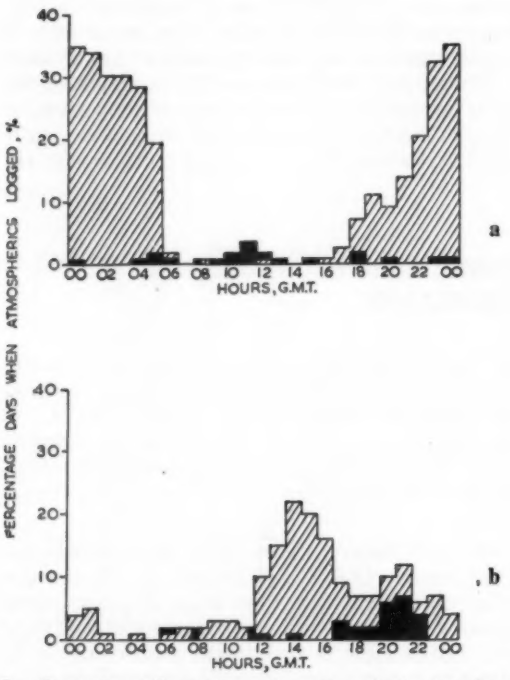
IT IS NOT UNCOMMON TO FIND THAT THE PERFORMANCE of a long-distance radio circuit is better in one direction than the other, even when there is no difference in the transmitting and receiving equipment at the terminal stations. For example, in summer the performance of the Capetown to London circuit deteriorates rapidly at about 1730 h G.M.T., but this is accompanied by only a comparatively small change in the reverse direction, as shown in Fig. 1. Asymmetrical performance of this kind also occurs in summer on the circuits coming in to London from Colombo, Singapore and Canberra, but with the

important difference that the farther east the distant transmitter is, the earlier in the day does the deterioration begin.



1 *Diurnal changes in performance of the Simonstown (Capetown)–London circuit (1951–54 inclusive)*

——— To London. – – – – From London.
The vertical line indicates time of onset of asymmetry.



2 *Percentage of occasions when atmospherics interfered with circuit operation, 1940–42*

(*a*) Reception from Capetown in London.
Summer, 1941. Winter, 1941–42.
(*b*) Reception from Melbourne in London.
Summer, 1941. Winter, 1940–41.

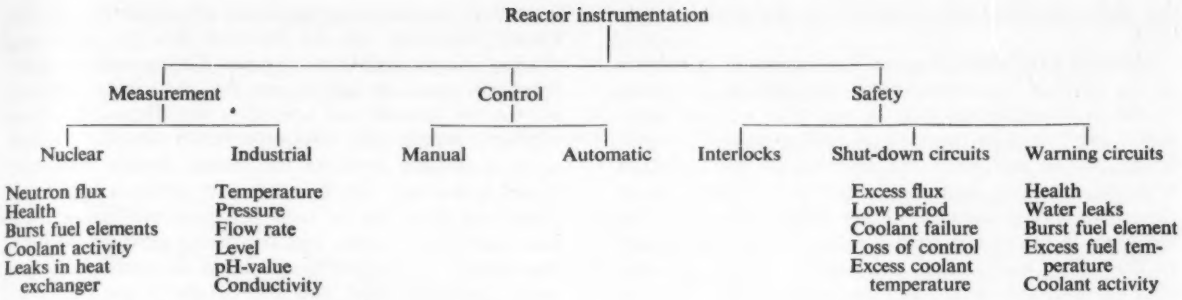
For each of the four circuits mentioned, the time at which the performance begins to fall can be explained by making two assumptions: (*a*) that deterioration is due to the daily peak of activity in one of the tropical thunderstorm areas which are known to be important sources of radio atmospheric interference, and (*b*) that the particular area which affects a given circuit is determined by the direction in which the beam of the receiving aerial is pointed. Some support for this hypothesis has been obtained from observations of atmospherics which were made in London using beam aerials directed towards Capetown and Melbourne. These results are shown in Fig. 2. In each instance the amount of atmospheric interference in summer does in fact increase rapidly at a time which agrees quite well with the deterioration of the corresponding radio circuit (Capetown, 1730 h; Melbourne, 0930 h). Some aspects of circuit asymmetry have not, so far, been explained in terms of atmospheric interference and it may be that other unknown complicating factors also play a part. 621.396.82

Reactor Instrumentation

A short review of a Measurement and Control Section paper (No. 2058) entitled 'The Control and Instrumentation of a Nuclear Reactor', by A. B. Gillespie, B.Sc. The paper was published individually in March 1956, and it is republished this month in Part B of the Proceedings.

THE INSTRUMENTATION OF A NUCLEAR REACTOR CAN BE subdivided conveniently under the headings of measurement, control and safety, and these in turn further broken down as shown in the family tree of Fig. 1. Many of the problems of instrument design are common with other industrial plant and follow conventional lines. Some, however, are more specialized and arise principally from the radioactive nature of the reactor and its unusual dynamic behaviour. A reactor can never be fully shut down. Owing to spontaneous fission, a small but finite power is maintained, which may be 6 to 10 decades lower than the operating power. It is essential to measure both the absolute power level and its rate of increase over the full range, and this can be realized only by a measurement of the neutron flux adjacent to the reactor core. Neutron-flux measurement provides a nearly instantaneous indication of the rate of heat generation within the core, and is thus also suitable for the operation of safety instruments which should be quick acting.

Ionization chambers feeding d.c. amplifiers provide the simplest method of measuring the neutron flux near to the core. Three types of d.c. amplifier are customarily used. The first is a conventional thermionic amplifier which measures the voltage developed across a high-value resistor by the ionization-chamber current. The wide power range is covered by switching the measuring resistor, usually in decade steps. The second is one pro-



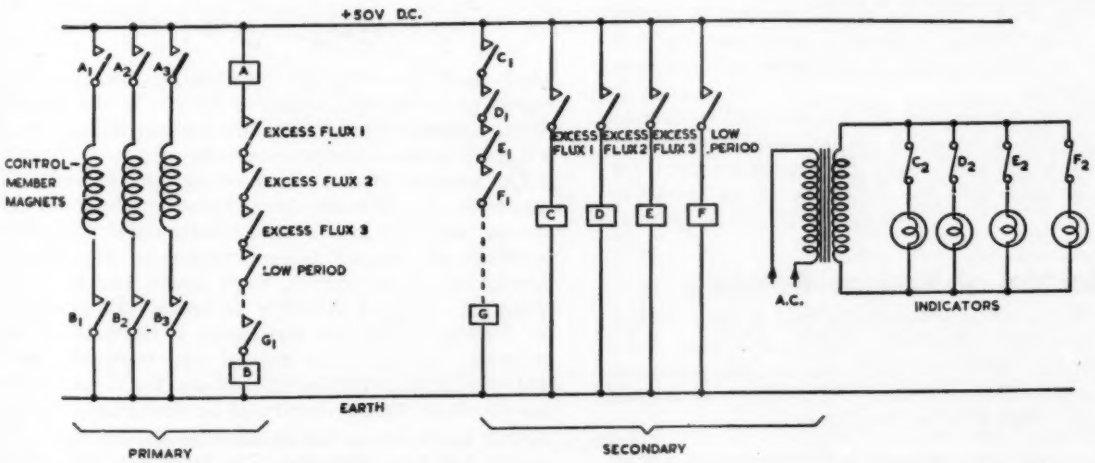
1 *Family tree of reactor instrumentation*

viding an output voltage proportional to the logarithm of the input current. This type of instrument is valuable, for the reactor power normally increases exponentially with time, and a differentiation of the linearly increasing output of a logarithmic d.c. amplifier gives a measure of reactor period, i.e. the time required for the power to increase by a factor ε (2·718 . . .).

The third type of d.c. amplifier is again a linear one, in which the output voltage is compared with a reference voltage, the difference giving a measure of the power error between the actual operating power and some demanded power which is initially set on the instrument controls.

Owing to the unavoidable sensitivity of the neutron ionization chambers to background γ activity, and also to the limited current range which can be covered by d.c. amplifiers of the types described, it is not usually possible to measure the full power range of the reactor with a single instrument, and two or more overlapping instruments may be used. Again, at very low neutron fluxes, γ activity may prohibit the use of mean-current ionization chambers completely, and here neutron-pulse-counting equipment must be used. The latter instrument provides better discrimination between neutron and γ radiation, as it is possible to separate the infrequent but large neutron pulses from the more frequent but smaller γ pulses, prior to measurement.

The nuclear reaction may be controlled by varying the amount of neutron-absorbing material in the core, by varying the amount of fuel, or by altering the position of a neutron reflector just outside the core. The first method is the one most frequently adopted. Absorbing rods are usually split up into three groups designated safety, shut-off and regulating rods. The first two groups are essentially emergency elements which are normally held right out of the core, but which can be dropped in quickly to provide a rapid shut down. The regulating rods are responsible for the short-term dynamic control of the reactor and must therefore be capable of variable-speed operation in either direction. Amplidynes and Velodynes have been used on some reactors to provide this facility. More recently two-phase induction motors, controlled by magnetic amplifiers, have been preferred, as this system of control gives certain material advantages, e.g. freedom from brush interference and an upper speed limit which cannot be exceeded. Under manual control the regulating rods are adjusted by the operator from the control desk, in response to readings on his power-level instruments. It is also possible to use the power-error signal to move the regulating rods automatically in



2 *Simplified arrangement of shut-down circuits*

the right direction to maintain a constant power level.

The safe operation of a nuclear reactor is a subject of the highest importance, and the purpose of much of the instrumentation is to ensure that no fault condition can result in the reactor getting out of control. Many of the fault-detecting instruments are common with the measuring instruments, but many others require their own special detectors. Fault information from the detectors is fed to the reactor safety circuits. This part of the safety instrumentation consists largely of relay circuits designed in accordance with a basic code or philosophy of reactor safety.

Interlock circuits are designed to ensure that the operations leading to the starting up of the reactor, and raising it to power, are carried out in the correct sequence, and that this sequence cannot be violated in any way.

The reactor shut-down circuits come into operation on the occurrence of a serious fault condition and cause the reactor to be shut down automatically. The fault detection initiates a sequence of electrical events which terminates in an interruption of the current supply to the magnet supporting the safety elements, and allows them to fall freely into the reactor core. Fig. 2 shows a simplified schematic of the shut-down circuits used on a number of small experimental reactors at Harwell. The primary safety line, containing contacts operated by the fault detectors, is monitored for continuity by relays A and B. A break occurring in this line shuts the reactor down by virtue of the A and B contacts in the safety-element magnet circuits. The secondary safety line is made up of a series arrangement of contacts of the relays C, D, E, . . ., each relay separately monitoring the fault-detector contacts. A break in this line will also open the primary line via relay G, while second contacts on C, D, E, . . ., are used to operate fault-identification indicators.

The possible failure of the fault-detecting instruments themselves raises the problems of accidental shut down and failure to shut down on the subsequent occurrence of a genuine fault. These are usually avoided by having multiple fault-detecting instruments and arranging that a reactor is shut down only by operation of more than one instrument.

The reactor warning circuits are designed to operate and to identify faults which are not sufficiently serious to warrant a full shut down. The warning circuits are usually identical with the secondary group shown in Fig. 2.

539.172.4 : 621.039.4 : 621.317.7 : 621–52

The Control of Nuclear Reactors

A short review of a Measurement and Control Section paper (No. 2068) with the above title by R. J. Cox, B.Sc., and J. Walker, M.A., Associate Member. The paper was published individually in March 1956, and it is republished this month in Part B of the Proceedings.

THE PAPER REVIEWS THE PHYSICAL PRINCIPLES WHICH affect the design of the control and instrumentation systems of nuclear reactors. Data are presented for the kinetic behaviour of the neutron flux for reactivity changes in a variety of reactor types. The nuclear reactions inherently produce various nuclides, the effects of which on reactor control and operation are discussed. These nuclides include the delayed-neutron emitters, which cause a slowing down of the reactor kinetic response; β and γ emitters, which continue to produce heat for a long time after the neutron reactions producing them have been shut down; and the fission-product poisons. Reasons are given for the system of neutron-flux instruments normally used, and also details of the principles of design of the various types of instrument.

As the result of the fission of a fissile atom by a neutron, more than two further neutrons are emitted. If one of these can produce a further fission, a chain reaction is produced. A system in which this chain reaction can be controlled is called a nuclear reactor. The growth or decay of the neutron population in such a system will depend upon the ratio of neutrons produced in one generation to those produced in the next. This ratio is known as the effective reproduction constant K_{eff}.

In one generation the number of neutrons increases by a factor $(K_{eff} - 1)$, since one neutron is required to initiate the next fission, and hence the generation rate due to fission, with a total neutron population n, will be

$$\frac{dn}{dt} = \frac{n(K_{eff} - 1)}{\tau} \quad . \quad . \quad . \quad . \quad (1)$$

where τ is the average time between successive generations. It can be shown that the power generated by a reactor is proportional to the neutron population.

Thus equation 1 shows that the rate of change of neutron population or power can be controlled by varying the value of K_{eff}. The quantity $K_{eff} - 1/K_{eff}$ is called the *reactivity*. When the reactivity is zero ($K_{eff} = 1$), the rate of change of power is zero, and therefore the power remains constant.

Integrating equation 1 gives

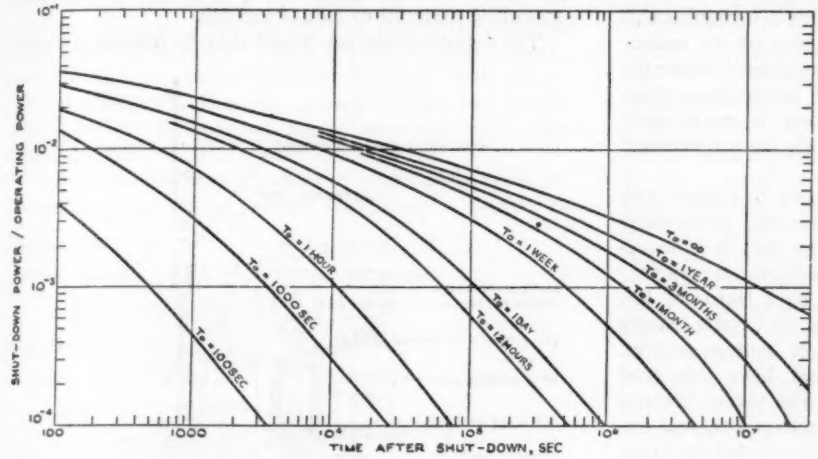
$$n = n_0 \exp\left[\left(\frac{K_{eff} - 1}{\tau}\right)t\right]$$

where n_0 = the neutron population at time t, so that when the reactivity is positive ($K_{eff} > 1$) the reactor power increases exponentially, and correspondingly when it is negative decreases exponentially.

The number of neutrons produced per second in a reactor is n/τ. However, each fission produces on the average about $2\frac{1}{2}$ neutrons, and the number of fissions produced per second is proportional to the neutron population of the reactor. Each fission results in the liberation of about 200 MeV of energy (about $8{\cdot}9 \times 10^{-18}$ kWh) but not all this energy is liberated instantaneously. About 6% is emitted later owing to the β and γ emission of the fission products. Fig. 1 shows how this source of heat is distributed in time after a reactor is shut down, for a variety of times during which the reactor has been operating. The most important effect this has on reactor technology is to make necessary the

provision of cooling at all times, as this heat can never be switched off.

Not all the neutrons produced by fission are released immediately. Some are emitted later by the new atoms produced by the fission. Six groups of such delayed neutrons are known, and data are presented in the paper of their half-lives and yields for the fuels U^{233}, U^{235}, U^{238} and Pu^{239}. In a heavy-water-moderated reactor, the high-energy gamma rays can produce neutrons by the so-called photo-neutron reaction with heavy-water. Data are presented for the yield and half-life of eight such photo-neutron groups for a typical U^{235} heavy-water system.

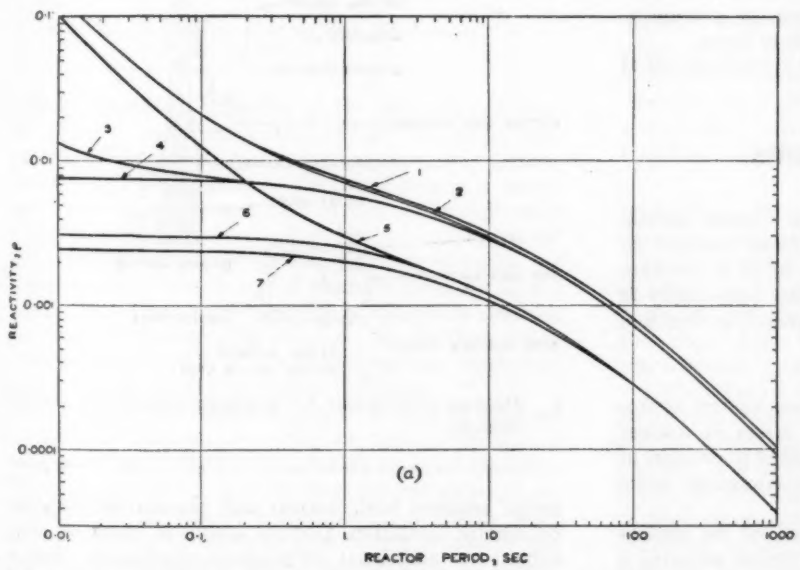

SHUT-DOWN POWER / OPERATING POWER
TIME AFTER SHUT-DOWN, SEC
T∞ = ∞
T∞ = 1 YEAR
T∞ = 3 MONTHS
T∞ = 1 MONTH
T∞ = 1 WEEK
T∞ = 1 DAY
T∞ = 12 HOURS
T∞ = 1 HOUR
T∞ = 1000 SEC
T∞ = 100 SEC

1 *Fission-product heat from irradiated uranium*

The kinetic behaviour of the reactor is considerably slowed up by these delayed neutrons, and the basic reactor kinetic equations are presented in the paper.

Fig. 2 shows the relationship between the reactivity ρ and the reactor period T_ε for typical fast-neutron and thermal-neutron systems using uranium and plutonium as fuel; it will be noticed that the relationship between ρ and T_ε is almost identical for all reactors using the same fuel, so long as ρ is less than the delayed-neutron fraction β for the fuel concerned. The significance of this is that fast and thermal reactors are indistinguishable by an operator, each having the same response to similar changes in control movement.

The most significant fission product from the control aspect is xenon, which has a very high capture cross-section for thermal neutrons. It is not a direct product of fission, but arises from the decay of tellurium 135. Because of its mode of formation and decay, the xenon 135 concentration in a reactor at steady neutron flux will build up to an equilibrium in which formation and decay rates are equal. If the flux level is changed a new equilibrium will be found, but the change in concentration during the transient may be very large. A chart for estimating peak values of the xenon-poison reactivity after a change in flux in the reactor Dido is given in the paper.



2 *Relationship between reactivity and reactor period for typical systems*

1 Dido. 2 Bepo. 3 Lido. 4 Zeus. 5 Theoretical (plutonium 239, thermal). 6 Zephyr. 7 Theoretical (plutonium 239, fast).

The importance of this phenomenon increases markedly as fluxes exceed 10^{13} n/cm²/sec, and it may completely prevent further operation for several hours after such a reactor has been shut down. Its effect will also be felt if the reactor is required to operate occasionally at part-load, as may well be the case in a mobile reactor intended for ship or aircraft propulsion.

During the start-up phase of reactor operation, the reactivity determines the rate of change of nuclear power, and control elements are therefore accelerator controls. When the nuclear power has reached a level producing significant temperature effect, the reactivity will be reduced by the effect of the increase in temperature. The *position*

of the control elements now determines the power level.

It is desirable to increase the reactivity of a reactor at a uniform rate, rather than in discrete steps, and, it should be added, at a rate that can be guaranteed never to exceed a safe value. The criterion for determining this maximum safe rate depends considerably on the reactor design. In the paper one example is considered where the stabilizing influence of the effect of temperature upon reactivity is exploited. This criterion is particularly applicable to power reactors in which the temperature rise is high.

Arguments are presented in the paper to explain why neutron-flux measurements are necessary, particularly during the start-up phase. It is shown that in a heavy-water reactor the neutron flux to be measured may vary between shut down and full power by a factor of 10^6. In other reactors it can be as high as 10^{14}, but is usually reduced to about 10^8 by the addition of neutron sources.

Reactor-instrumentation techniques have advanced considerably in the past few years. The use of neutron sources has reduced the range of neutron flux, and improvements in electronic circuits have extended the lower limit of flux level that can be measured under plant conditions. Improvements in the neutron detectors, together with the use of lead shields, have reduced the effect of γ-ray backgrounds. These advances, together with a better understanding of the requirements for siting neutron detectors, have led to the belief that in any reactor type the neutron flux can now be measured from shut down to full power. This being so, it becomes part of reactor-control philosophy to display neutron flux and its rate of growth or decay to the operator at all times. The form of the display has been developed for operational convenience, and it is felt that this system of instrumentation is likely to remain for some time to come.

539.172.4 : 621.039.42 : 621–52

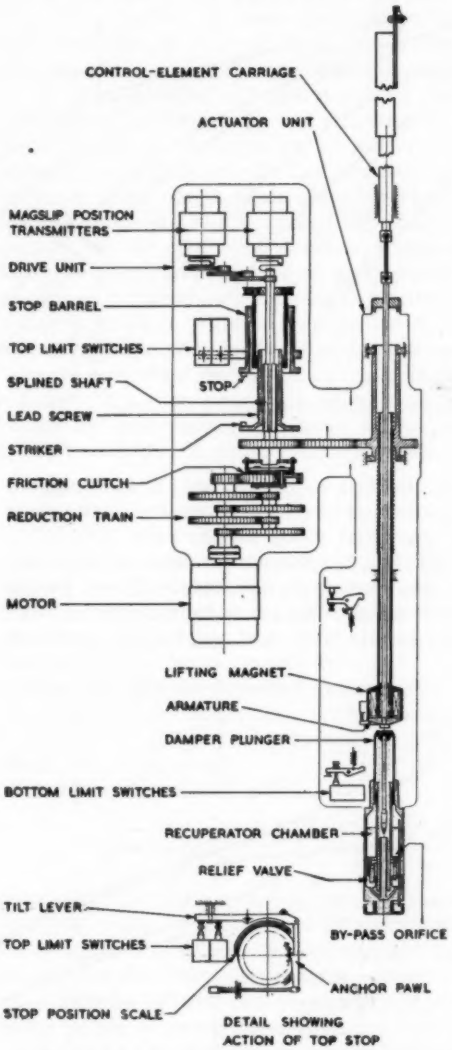
Reactor Control Mechanisms

A short review of a Measurement and Control Section paper (No. 2046) entitled 'Some Design Aspects of Nuclear-Reactor Control Mechanisms', by G. E. Lockett, A.M.I.Mech.E. The paper was published individually in March 1956, and it is republished this month in Part B of the Proceedings.

THIS PAPER IS INTENDED TO OUTLINE SOME OF THE DESIGN requirements for control-mechanism drives in nuclear reactors, and although the scope is limited to reactors of low and moderate power, many of the comments relate to reactors of all classes.

For steady reactor output, fissioning of the nuclear fuel continues at a steady rate, each fission releasing a number of neutrons of which one is used to create further fission, the excess neutrons in each generation are lost from the system by absorption in the various reactor materials or by leakage, and control is achieved by moving elements which alter either or both of these losses, e.g. reactivity may be increased either by removal of an element containing a neutron-absorbing material or by the insertion of an element containing fuel or neutron-scattering material to reduce leakage.

The complete control, which may be manual or automatic, requires both nuclear and physical information on reactor condition. Control action is based on this, subject to additional information confirming that a number of safety requirements are being met. Should any control information be lost, or any safety requirement be violated, then normal control must cease and

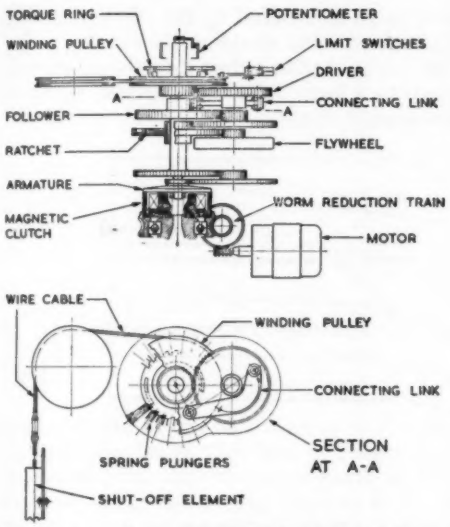


1 *Diagram of drive unit for combined control and shut-off elements*

a trip must occur which will cause the reactor to shut down immediately; since this relies on movement of control members, the design of these items and their release system must aim at complete reliability.

Although no chance of losing control should be allowed to occur, a reactor must be inherently stable so that temperature will set a limit to the maximum possible power which can be developed in the event of an uncontrolled divergence. This may damage the reactor, but the effects will be limited and can be localized by suitable plant design.

To shut down a reactor a number of primary or shut-off elements are required, which contribute a degree of



2 *Diagram of operating head for shut-off elements*

control adequately exceeding all the possibilities leading to reactivity gain. These elements are invariably supported against gravity by an electromagnet, or magnetic clutch, which is energized by the completion of a reactor safety-circuit, and interruption of this circuit will cause a trip shut-down.

To regulate the reactor some control elements are required which can be moved in either direction at any speed up to a safe maximum. These regulation elements are often independent, but they may also be designed to fulfil the combined function of shut-off and regulation. This is usually done where space is limited.

Although for shut-down purposes the primary elements control the reactor, an additional safety function is satisfied by the inclusion of secondary or safety elements. These are similar to shut-off elements but they are set 'ready' when the reactor is shut-down before any work such as loading or servicing can be performed; if the reactor diverges through some unforeseen train of events, some control is ready for tripping and a rapid shut-down is possible.

In addition to protection given by monitoring the reactor state, the operator must be protected by suitable interlocking at each stage from carrying out an incorrect starting-up sequence. A number of conditions must apply: ancillary services must be operating and all instruments must be functioning before control elements can be moved. The movement of control elements must ensure that the possible reactivity addition rate which can be applied to the system is restricted to a carefully chosen maximum.

So that the operator may continually observe the effect of his actions, not only must power level and reactor period be continuously indicated but the position of any control element must be displayed at the controlling point, together with limit-position indication. These requirements necessitate a number of built-in features in each control drive mechanism in the form of limit switches and position-indicating transmitters. In addition there are a motor-drive and gear-reduction train, the magnet-release system, and the braking system for meeting the rather exacting requirements of bringing a falling control element smoothly to rest after release.

The practical solution of the control problems will vary widely between different types of reactor, and in some it will have the added complexity of penetrating a sealed reactor vessel. The problem of cooling the elements will also occur in many reactors. Figs. 1 and 2 show the control drive mechanisms used on Zeus, the latest Harwell fast reactor built for zero-energy experiments.

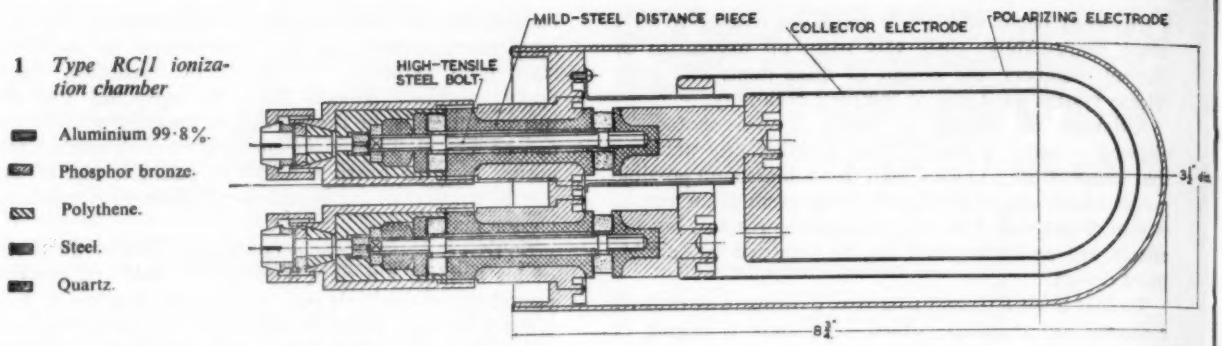
621.039.42 : 621–52

Thermal-Neutron Detector

A short review of a Measurement and Control Section paper (No. 2029) entitled 'Nuclear-Reactor-Control Ionization Chambers', by W. Abson, B.Sc., Associate Member, and F. Wade, Associate. The paper was published individually in March 1956, and it is republished this month in Part B of the Proceedings.

IONIZATION CHAMBERS CONTAINING BORON AS THE detecting medium for thermal neutrons are widely used in nuclear-reactor instrumentation systems. The boron 10 isotope has a high capture cross-section for thermal neutrons, and the compound nucleus disintegrates into two short-range ionizing particles—a lithium nucleus and a helium nucleus (α particle).

Fig. 1 shows a section of an ionization chamber (type RC/1) which has been developed for use in U.K.A.E.A. thermal power reactors and in a variety of experimental reactors. It is suitable for use with boron trifluoride gas fillings or with thin coatings (approximately 1 mg/cm^2) of elemental boron on the surfaces of the electrodes. As the range of the ionizing particles is equivalent to a thickness of the order of only 1 mg/cm^2, the use of thicker coatings would not produce any increase in sensitivity. The ionization produced in the gas between the two cylindrical electrodes is collected by applying



1 *Type RC/1 ionization chamber*

a voltage to the outer polarizing electrode, the inner electrode being connected to the input of a d.c. amplifier.

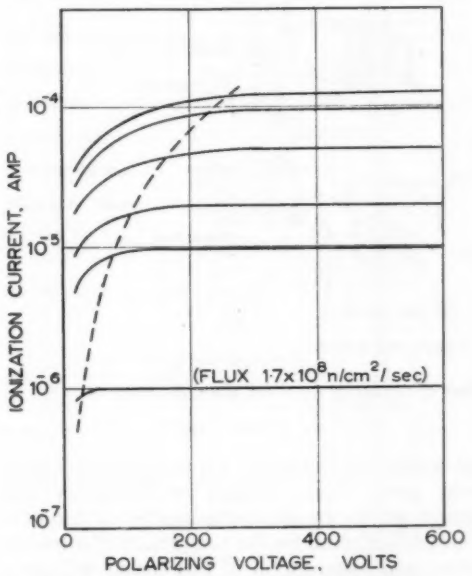
In nuclear-reactor-control instrumentation systems the neutron-flux measurements are used to provide a measure of reactor power. There will in general always be other radiations (gamma and beta radiations) from fission products and from induced activities which are not proportional to the instantaneous reactor power, and it is therefore necessary to ensure that the ionization current due to these radiations is negligible compared with that due to the neutron flux, over the range of measurement required. The neutron and gamma-radiation sensitivities of a boron-lined ionization chamber are given in the Table. If boron enriched in the boron 10 isotope is used, the neutron sensitivity is increased by the enrichment factor, but the gamma-radiation sensitivity is not affected. Hydrogen is used as the filling gas because this gives the highest ratio of neutron/gamma sensitivity.

Neutron and Gamma-Radiation Sensitivities for Boron-Lined Ionization Chambers.

Hydrogen pressure	Neutron sensitivity	Gamma-radiation sensitivity	n/cm²/sec equivalent to 1 r/h	Flux for 99·8% saturation with polarizing voltage of 250 volts
cm Hg	amp/n/cm²/sec	amp/r/h		n/cm²/sec
150*	6×10^{-15}	6×10^{-12}	$1{\cdot}0 \times 10^{3}$	$1{\cdot}7 \times 10^{9}$
70	$4{\cdot}5 \times 10^{-15}$	$2{\cdot}9 \times 10^{-12}$	$6{\cdot}5 \times 10^{2}$	5×10^{9}
40	$3{\cdot}1 \times 10^{-15}$	$1{\cdot}6 \times 10^{-12}$	$5{\cdot}2 \times 10^{2}$	$1{\cdot}4 \times 10^{10}$
15	$1{\cdot}5 \times 10^{-15}$	6×10^{-13}	$4{\cdot}0 \times 10^{2}$	$7{\cdot}5 \times 10^{10}$

*At 150 cm Hg neutron sensitivity is approximately 90% of the maximum possible value.

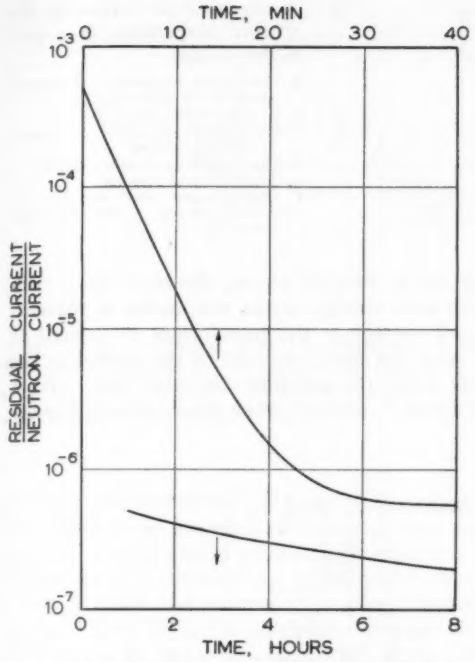
The applications of neutron-flux-measuring channels in reactor control falls into two main classes—high-level operation and control during starting up from sub-critical levels. The upper limit of flux measurement is usually governed by the ionization-collection characteristics. Fig. 2 shows typical characteristics for a chamber filled with hydrogen under a pressure of 150 cm Hg. Lower gas pressures are usually required in order to achieve adequate collection at flux levels of the order of 10^{11} n/cm²/sec (see Table). By the use of appropriate coatings and gas fillings the same basic design of chamber can be used for flux measurements over a range of 10–10^{11} n/cm²/sec. In practice the lower limit of measurement is likely to be determined by the effect of gamma and beta radiations. Lead shielding around the ionization chamber can be used to reduce the external gamma-radiation fields by a factor of several hundred, with little effect on the neutron flux.



2 *Saturation characteristics of RC/1 chamber. Both electrodes are boron coated, and the chamber is filled with hydrogen at a pressure of 150 cm Hg*

– – – – Polarizing voltage for 90% collection efficiency.

The effect of induced activities in the ionization chamber, however, can be controlled only by a suitable choice of constructional materials. High-purity aluminium is used in the type RC/1 design, and the minimum practicable quantity of materials of high activation cross-section has been used in the sealed insulator components. Aluminium has a comparatively low activation cross-section coupled with an activation half-life of 2·4 min. Fig. 3 shows the decay of the residual current (due to the radioactivity of the ion-chamber) following the removal of neutron flux after three months' irradiation. After a



3 *Residual-activity current following removal from neutron flux*

period of 30 min the radioactivity of the aluminium is negligible compared with that of longer-lived activities from impurities and the components of the insulator, the residual current having fallen to $6{\cdot}5 \times 10^{-7}$ times the original neutron current. With a boron 10 coating and a hydrogen pressure of 15 cm Hg the effect after 30 min is still lower (5×10^{-8}), so that the chamber could then be used for control during starting up from about 5×10^{-7} times the previous power level.

621.387.422 : 539.172.4 : 537.542

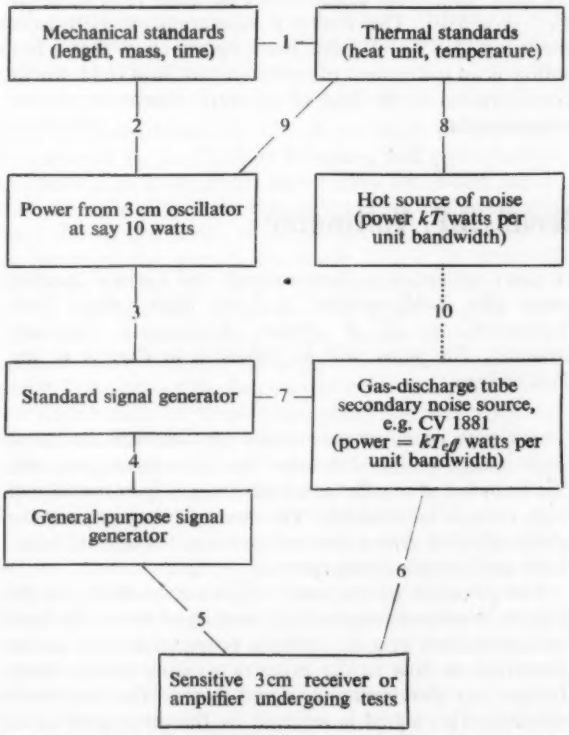
Microwave Noise Measurement

A short review of a Radio and Telecommunication Section paper (No. 2130) entitled 'Noise Measurements in the 3 cm Waveband using a Hot Source', by H. Sutcliffe, M.A., Associate Member. The paper is published this month in Part B of the Proceedings.

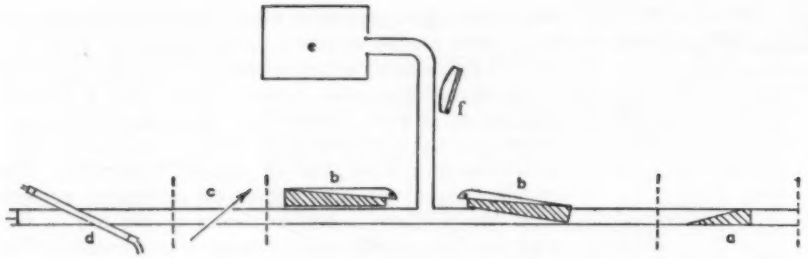
THE PURPOSE UNDERLYING THE SERIES OF MEASUREMENTS described in the paper may perhaps be best understood by reference to a diagram such as Fig. 1. This consists of a number of descriptions of equipment used in the field of microwave measurement, linked together by ten lines, each denoting some process of measurement or calibration and numbered for ease of reference.

A sensitive receiver is tested (link 5) by a convenient and robust signal generator, which in turn is calibrated (4) by a more precise standard signal generator. Tests for receiver noise factor are performed conveniently (6) using a discharge-tube noise source, which has a known effective noise temperature T_{eff}. The value of T_{eff} may be determined experimentally (7) by a standard signal generator and a receiver of known bandwidth. The standard signal generator requires a calibration derived from the primary standards shown at the top of the diagram. The absolute measurement of microwave power can be achieved by a torque-operated wattmeter (2) or a calorimeter technique (9). Both these methods are best suited to power levels of 10 watts or more, while the measurements directly concerned with receiver tests (4, 5, 6, 7) are typically at a level of 10^{-14} watt, and so the calibration of the standard signal generator (3) involves the design and construction of extremely precise waveguide attenuating circuits.

An alternative route to low-power measurements is available on the right-hand side of the diagram. Thermodynamic reasoning (8) has established the quantity of noise power emitted by a hot matched waveguide source, while a particular gas-discharge tube, the CV 1881, has been developed in a form in which it has very stable and reliable properties. Measurement of its effective temperature by comparison (10) with a hot source can therefore provide an independent check on the accuracy of the original routes (2, 3, 7 or 9, 3, 7).



1 *The relations between microwave power measurements and primary standards*



2 *Arrangement for measuring the effective temperature of a gas-discharge tube*

a Hot source, temperature T_s (600° C above room temperature).
b Arm-blocking attenuators.
c Calibrated attenuator in region 12–13 dB.
d Discharge-tube, temperature T_{eff}.
e Amplifier and detector.
f Quarter-wave line stretcher to reduce errors from imperfect matching.

The paper describes a noise-temperature calibration of this type. Fig. 2 shows, in diagrammatic form, the equipment used. The calibrated attenuator is adjusted until no change in the noise power fed to the receiver is detected as the arm-blocking attenuators change over. Then:

$$(T_{eff} - T_r)A = T_s - T_r$$

where T_r is room temperature, T_s is the temperature of the source, and A is the attenuation expressed as a ratio less than unity.

It is customary in practice to quote effective temperatures in the form θ_{eff}, where

$$\theta_{eff} = 10 \log_{10} [(T_{eff}/T_r) - 1]$$

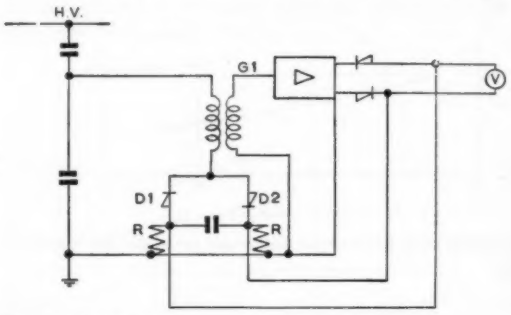
since their measurement and use arise conveniently in this form. The value of θ_{eff} for a particular batch of CV 1881 tubes was established (via links 7, 3, 9, 8) as $15{\cdot}5 \pm 0{\cdot}5$ dB. The author's measurements (10) gave the value $15{\cdot}75 \pm 0{\cdot}3$ dB. These figures show that a hot source is an instrument of sufficient precision to be worth consideration in the field of standard microwave power measurement. 621.317.382

Novel H.V. Voltmeter

A short review of a Measurement and Control Section paper (No. 2145) entitled 'A Novel High-Voltage Peak Voltmeter', by W. P. Baker, B.Sc.(Eng.), Associate Member. The paper will be published in Part A of the Proceedings.

A NEW TYPE OF CREST VOLTMETER SUITABLE FOR USE WITH high-voltage potential dividers has been developed, and has been found to offer some advantages over traditional high-voltage instruments. The main advantages are the elimination of errors due to frequency variations, waveform and corona discharges.

The principle of the new instrument is shown in the Figure. An alternating voltage developed across the low-voltage section of a capacitance potential divider causes a current to flow in the primary winding of the transformer, so developing a signal across the secondary winding. This signal is received by the input grid G1 of the amplifier, which delivers an output direct voltage, which is in turn fed back to the rectifiers D1, D2 in the input transformer primary circuit, the sense being such that the forward voltage across the diodes is reduced. The primary current in the transformer is reduced in turn, and so is the signal received by the amplifier. The d.c. output from the amplifier therefore falls, and a stable condition is obtained when the double-amplitude-



New peak voltmeter

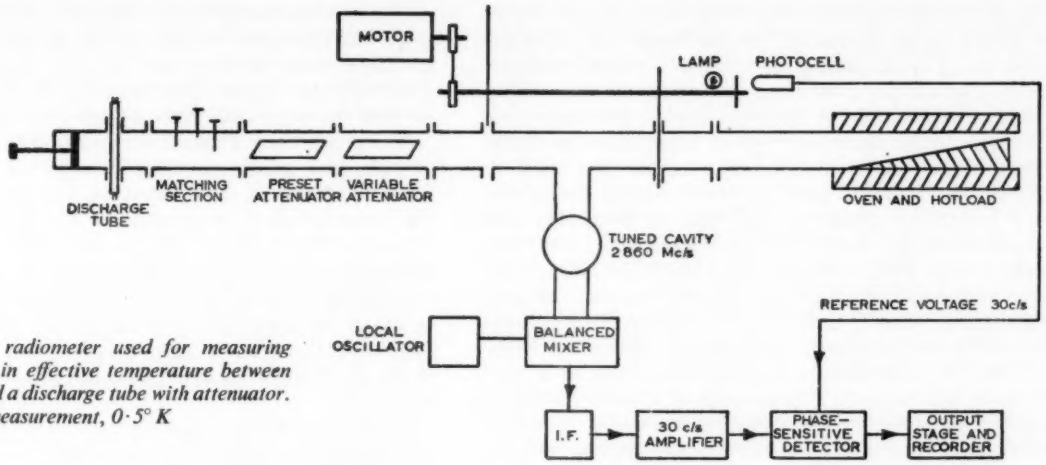
peak input voltage is just sufficiently greater than the bias direct voltage on the rectifier to provide enough signal at the amplifier input to produce the bias voltage.

A d.c. instrument measuring the bias direct voltage gives, therefore, an indication directly proportional to the double-amplitude-peak input voltage being measured. All variable elements such as the rectifiers, valves, etc., are in the feedback loop, so that the indication is not influenced by changes in their characteristics. Sufficient amplification can readily be provided to render the error (double-amplitude-peak voltage minus bias direct voltage) negligibly small compared with instrument and potential-divider errors. 621.317.726

Standard Temperature Noise Source

A short review of a Radio and Telecommunication Section paper (No. 2125) entitled 'Absolute Calibration of a Standard Temperature Noise Source for Use with S-Band Radiometers', by V. A. Hughes, M.Sc. The paper is published this month in Part B of the Proceedings.

RADIOMETERS HAVE BEEN DEVELOPED AT MICROWAVE-lengths for the purpose of measuring the small amounts



Schematic of radiometer used for measuring the difference in effective temperature between a hot load and a discharge tube with attenuator. Accuracy of measurement, 0·5° K

of radio noise power received from astronomical sources. The power levels involved are normally very much less than the inherent noise produced in receivers, and the measurement is achieved by comparing with a known source of noise and integrating over a sufficiently long period of time. Thus it is possible to measure changes in noise power at levels of about 10^{-4} of receiver noise powers, corresponding to the difference in thermal or Johnson noise from two resistors differing in temperature by only a fraction of 1° K. It is desirable to calibrate radiometers in terms of temperature, and for convenience and versatility a standard source is required, the effective temperature of which may be varied rapidly over large values. At metre wavelengths the shot noise from a saturated diode is used, but at microwavelengths a suitable source appears to be the radiation from an argon discharge tube, such as the CV1881, in series with a precision attenuator. Previous measurements of the noise output of this tube against c.w. sources indicated a value (kTB) of about 10^{-13} watt per megacycle of bandwidth, corresponding to an effective temperature of about 10^4 °K; but, since standard c.w. power measurements are made at levels of about 1 watt with an optimum accuracy of about 1%, the accuracy of measurement at levels 130 dB below this value was not very high. On the other hand, a heated load provides an absolute noise-power standard, the temperature of which may be easily measured to an accuracy of about 1° K in 500° K, and the difference in power levels is now only about 17 dB.

This paper describes the radiometer, which is shown in the Figure, and the technique for calibrating the argon discharge tube CV1881 against the noise from a thermal load; the tube was in an E-plane waveguide mount, and the frequency was 2 860 Mc/s. The results indicate that the effective temperature of the tube is 11 140° K with a maximum error of 260° K; the stability and consistency of the tubes measured were exceedingly good, four tubes giving the same output to within 0·01 dB and two deviating by 0·02 dB and 0·03 dB respectively. In comparison mercury tubes showed large deviations. The CV1881 also provides the ideal source for measuring the inherent noise level in receivers. 621.317.382

Lighting

Some notes on a review of progress (Paper No. 2132) with the above title by J. W. T. Walsh, O.B.E., M.A., D.Sc., Member. The paper was published in August 1956, in Part A of the Proceedings.

THE LAST INSTITUTION REVIEW OF PROGRESS IN LIGHTING was written by Sir Clifford Paterson, and published in the *Journal* in 1940. In his new review Dr. Walsh states that the most important development in light measurement during the period under review is the adoption of an international primary standard. This is in terms of luminous intensity per square centimetre of a black body at the solidification temperature of platinum, the unit being termed the *candela*. Other points noted by the author under 'General Principles and Measurements', which is the title of the first section of the review, include the replacement of visual photometry by photo-electric methods, changes of nomenclature, e.g. *luminance* instead of *brightness*, and the fact that an extensive international lighting vocabulary in English, French and German is shortly to be published by the C.I.E.

The second section covers lamps, and there is little new to note on tungsten-filament lamps, apart from the diffusing bulb coated with silica. Dealing with discharge lamps, Dr. Walsh says that the most spectacular development is the introduction of the electronic flash lamp, in which a heavy discharge takes place in a xenon-filled tube. Colour-corrected mercury-vapour lamps are also an innovation, and the author forecasts their greater use for street lighting in Britain.

The widespread introduction of the fluorescent lamp

is undoubtedly the most important recent development in light sources. Before the Second World War the only kind available in Britain was the 5 ft 80-watt tubular lamp. The enormous demand during the war for better lighting in blacked-out factories caused production to be concentrated on this one type of lamp, with a resulting check to lamp development. Since the war there has, of course, been much progress in introducing new phosphors and improving efficiency and life. In discussing the colour-rendering properties of fluorescent lamps the author notes that, contrary to a widespread belief, very little ultra-violet radiation is emitted from the ordinary fluorescent lamp. Cold-cathode lamps, which are increasing in popularity, are treated briefly, and the section on lamps concludes with a reference to a new form of light source. This consists of a condenser with one transparent plate and dielectric made of a phosphor that can be caused to glow by a suitable electric field.

Section 3 of the review covers fittings, and here the chief development to record is the introduction of light alloys and plastics, the latter being used to replace both metal and glass. Britain has undoubtedly led the world in the use of fluorescent street lighting, and the rapid increase in installations has given rise to many new types of fitting which extensively use plastics.

'Interior Lighting' is the title of Section 4, and here Dr. Walsh calls attention to the recommendations of the I.E.S. Code for Lighting in Buildings. He points out that the assessment of lighting quality as distinct from the amount of illumination provided is extremely difficult. Glare is a most important factor, and attempts have been made to arrive at a formula for a *glare index*, taking into account the luminance and angular size of the source in relation to the background luminance. In Britain much work has been done on this subject by asking observers to judge under continuously variable conditions when glare becomes (*a*) just imperceptible, (*b*) just acceptable, (*c*) just uncomfortable, and (*d*) just intolerable.

There has been a great improvement in the lighting of industrial premises, which has been helped by the widespread use of the fluorescent and mercury-vapour discharge lamps. It is common to use to-day values of illumination five to ten times as great as in 1939. In the home, too, there is a tendency towards the use of higher-rated lamps. The author points out that of all industrial locations the most difficult to light is the coal mine; even to-day the miner's portable lamp, which is now electric, is by far the most important lighting source at the coal face.

The final section of the review covers exterior lighting, which includes street lighting, aerodrome lighting and flood-lighting. The author notes that automatically controlled street lighting is now almost universal, some type of time switch generally being used, though other systems include the application of photocell or radio control. The design of airport lighting has made great strides since 1945, and in 1952 a British Standard Guide to Civil Aerodrome Lighting was published; this takes account of the I.C.A.O. recommendations on the subject.

Dr. Walsh's review of lighting is a very readable account of recent progress in the subject, and members who are not specialists in the subject but who wish to bring themselves up to date on it are recommended to obtain the relevant copy of the *Proceedings* or a separate reprint of the paper. 628.9

Papers read at the Convention on Digital-Computer Techniques, April 1956

The remainder of the short reviews published this month is a second selection of reviews of papers read at the Convention on Digital-Computer Techniques, which was held by The Institution from the 9th to 14th April 1956. The papers reviewed here were all read at General Sessions of the Convention. Further selections of reviews of Digital-Computer papers, including those read at the Specialist Sessions, will be published in future issues. The complete papers will be published in a special supplement to the *Proceedings*, as announced in the July *Journal*, p. 446.

Routines for Control Systems

Paper No. 2066 entitled 'Use of Interpretation Routines on a General-Purpose Digital Computer for the Design of Linear and Non-Linear Control Systems', by W. D. Worthy, M.A., Associate Member.

SERVO-MECHANISM DESIGN NECESSITATES THE CHOICE OF suitable amplification and damping factors to achieve a satisfactory speed of response and rapid settling time. For all but the simplest systems, calculation is troublesome, and simulators are widely used so that parameters may be varied conveniently, and an optimum design obtained by experiment.

For complex and non-linear systems special components are needed, and the simulator becomes more expensive and essentially a special-purpose machine. Many engineering companies may therefore find it more expedient to purchase a general-purpose digital computer which is more versatile and applicable to a much wider range of problems.

To match the convenience afforded by the simulator it must be possible to describe a control system in a simple and convenient form and feed this data directly into the digital computer. A programme has been written for this purpose, and when fed into the machine it will automatically interpret a description of the control system, compute the solution by step-by-step integration and then display the system response on a cathode-ray tube.

Consider, for example, a simple position-control system in which the restoring force is proportional to the displacement x, and viscous damping is provided proportional to the velocity v. If there is an additional load L the system may be described by the following equations with gain and damping constants λ and μ.

			1		2		3
4	dx/dt	=			$1 . v$		
5	dv/dt	=	$\lambda . x$	−	$\mu . v$	−	L

The system is completely described by the matrix of coefficients on the right-hand side of these equations. The columns corresponding to the variables x and v and the constant L may be labelled 1, 2, 3 and the rows corresponding to the derivatives of the variables may be numbered 4, 5.

The problem may then be presented to the computer as a set of coded numbers. In each group the first number specifies the magnitude of the coefficient, and the second and third specify its location by means of the column and row numbers. Thus only four number groups would be needed for this simple problem:

$$1, 2, 4 ; \lambda, 1, 5 ; -\mu, 2, 5 ; -L, 3, 5.$$

The paper describes the mathematical procedure, and shows how the scheme has been developed to cope with non-linear systems by including special instructions for the computer. The method is also applicable to other systems which may be described by a set of first-order simultaneous differential equations.

621.374.32 : 681.142 : 621–526

Power-System Problems

Paper No. 2121 entitled 'Power-System Engineering Problems with reference to the Use of Digital Computers', by C. Robinson, M.Sc., and D. H. Tompsett, B.Sc.(Eng.), Associate Member.

THERE ARE A NUMBER OF PROBLEMS IN THE DESIGN AND operation of power systems where digital computers could be used with advantage. Generally, such problems include those for which existing computational methods are prohibitive in time, or which demand gross approximations to achieve even a crude answer in a reasonable time.

One field in which the complexity of the analysis has precluded anything more than an approximate solution is the economic operation of an interconnected system. The main data may comprise the characteristics of the power system, the specification of one or more particular load conditions and the different incremental costs of energy at the various generating points. In thermal stations the latter is determined mainly by the cost of fuel and can be expressed as a function of the power generated. The complexity in the problem arises from the necessity to take proper account of the losses involved in transmitting the power from the generators to the loads.

In one possible formulation of the problem the losses can be approximately expressed as a quadratic function of the generated powers. The total cost of generation must then be made a minimum, subject to the overriding condition of meeting the total demand. The power to be generated at each station can then be uniquely determined. Mathematically, the problem reduces to a few matrix manipulations followed by finding the lowest latent root and vector of a matrix. These are operations particularly well suited to digital machines, and once the data are available the whole operation can be completed in a few minutes.

A more accurate but more complicated approach is to combine the iterative procedures involved in a load-flow study with those necessary to minimize the cost. Progress in this field now permits a very valuable tool to be made available to system operating engineers.

Another power-system problem is that of determining the shape of the load curves attributable to various individual classes of consumer. This information is of value in the formulation of tariffs and in system planning. On a large system, a number of substations will exist, and the loads supplied from each of these will comprise the different consumer classes in various proportions. If a continuous record is available of the total demand at each substation for a particular day, and if the energy consumption over a period of each class of consumer supplied on that day from each substation is known, then, by regression analysis, the best shape for the daily load curve for each class of consumer can be determined. Once again the mathematics may be neatly expressed in matrix notation, which so readily lends itself to digital computation with full checks on the accuracy.

The solution of simultaneous algebraic equations and simultaneous ordinary differential equations are two other tasks performed by digital computers. An example of the former is the familiar problem of determining the currents in a network resulting from the application of specified voltage or current sources. Two complicating features of such problems may be the need to deal with complex numbers and also 3-phase circuits having mutual coupling effects. Both of these can be readily accommodated in digital methods of solution.

Simultaneous differential equations, possibly including non-linear elements, can be handled at high speed compared with step-by-step hand calculations or graphical methods. Examples arise in switching operations or other transient circuit problems involving lightning-arrester operation, corona or saturated iron paths.

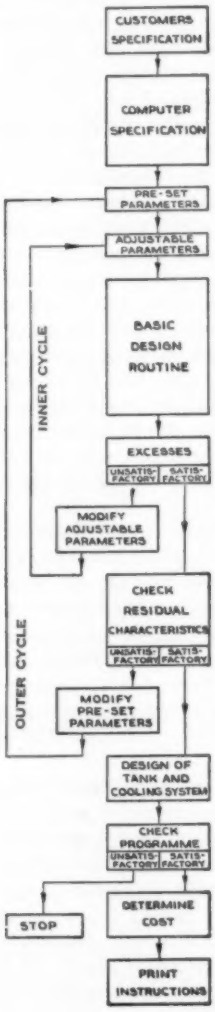
Digital computers are being successfully applied in the design of individual items of electrical plant and to problems in control engineering, statistical investigations and accountancy work. Many parallels exist between these fields and certain aspects of power-system engineering. Purely theoretical calculations may need to be modified

by engineering judgment, but this should be a rational procedure amenable to at least approximate quantitative expression. 621.311.1 : 681.142

Transformer Design

Paper No. 2159 entitled 'Transformer Design with Digital Computers', by J. V. Oldfield, B.Sc.(Eng.), D. McDonald, B.Sc., Associate Member, and M. W. Humphrey Davies, M.Sc., Member.

IN SOLVING ANY PROBLEM ONE MUST STUDY THE GIVEN data, examine the boundary conditions and go through a logical sequence of calculations to ensure that all the requirements are met. So it is in design, with the additional conditions of quality and economy superposed. The process of transformer design is the experienced manipulation of a number of significant quantities which are related in a complex way. The designer's manipulations may be set down in an order which enables a digital computer to carry out arithmetical calculations, to make logical decisions based on the results obtained and to modify the variables until a solution is achieved which satisfies all the necessary and sufficient conditions. The digital computer used in this way makes possible:



Flow diagram

(*a*) Very appreciable reduction in design time, which facilitates the preparation of new standard lines to meet ever changing conditions and the impact of new materials.

(*b*) Optimization studies of radically different designs to meet one set of requirements.

(*c*) Direct data processing, which at the moment occupies so much of the designer's time and effort.

(*d*) The achievement in the future of much better designs by embodying in the computer programme the best knowledge and experience of many specialists.

The paper sets out some details of an early approach to this application of digital computers, and the Figure shows a general flow diagram of the design process.

621.374.32 : 621.314.1/.3 : 518.5

Deuce

Paper No. 2096 entitled 'Deuce: a High-Speed General-Purpose Computer', by A. C. D. Haley, M.A., Associate Member.

THE IDEAL DIGITAL COMPUTER COMBINES SPEED OF calculation, large storage capacity for instructions and data, economy in electronic equipment, ease of operation, and reliability. Any practical computer is, of course, a compromise between these conflicting requirements, and the particular compromise chosen for the Deuce (Digital Electronic Universal Computing Engine) has proved highly successful in practice. Speed of calculation and economy are attained by the use of a mercury-delay-line computing store, operating at 1 Mc/s pulse recurrence frequency, in conjunction with serial arithmetic units. The latter, using a small amount of equipment to deal in turn with successive digits of a number, permit addition times of 64 microsec. and multiplication and division times of 2 millisec. The arrangement of the store, using a number of small-capacity units in addition to the main mercury delay lines, enables these speeds to be maintained without appreciable loss due to the necessity of reorganizing data within the store as calculation proceeds.

Additional storage is provided by magnetic recording on a drum having a capacity of over 250 000 binary digits. This is not connected directly with the arithmetic circuits, since the capacity of the mercury-delay-line store is adequate to allow a substantial amount of calculation without reference to the drum. Block transfers between the mercury lines and the drum can then be made at intervals during the calculation without significant loss of speed.

The total storage capacity of the computer is adequate for the great majority of scientific and technical calculations, and for many types of commercial and accounting work. Provision is made, however, for addition of magnetic-tape storage units which allow an almost unlimited storage capacity.

The standard form of input to and output from the computer is by means of conventional punched-card equipment, giving a rate of input and output in keeping with the computing speed, and allowing sorting and tabulation of the cards by means of standard machinery. The computer design makes provision for the use of alternative input and output media (e.g. punched paper tape or high-speed printer) if this is appropriate to a particular application.

A number of applications to electrical engineering are described in other papers presented to the Convention. These give some idea of the versatility of computers of this type, and an equally impressive list of applications could be quoted for almost any other branch of science or technology.

In the interests of economy of skilled effort, it is obviously desirable that unnecessary duplication of the work required to formulate and programme a computa-

tion should be avoided. There is ample evidence that the policy of recording and circulating programmes of general interest, including, of course, the subroutines of which any extensive programme is largely composed, has contributed greatly to the efficient application of machines of this type. 621.374.32 : 681.142

Mercury

Paper No. 2095 entitled 'Mercury: a High-Speed Digital Computer based on the Manchester University Mark II Computer', by K. Lonsdale, B.Sc.Tech., and E. T. Warburton, B.Sc., Graduate.

MERCURY IS A PRODUCTION COMPUTER WITH THREE LEVELS of storage; electromagnetic delay-line computing stores, magnetic-core fast-access main stores and magnetic-drum backing stores. It can accommodate up to eight magnetic drums with a total storage capacity of 1 310 720 bits. The drums are synchronized to the machine and operate serially at 200 000 bits/sec. Information is usually transferred to or from the main store in blocks of 1 280 bits, the transfer time being 6·4 millisec. The average waiting time is 8·6 millisec. If larger numbers of blocks are transferred sequentially the waiting time is not increased.

The fast-access programme and numerical store is a 40 960-bit magnetic-core store. It operates in ten parallel channels each working at 100 kc/s in a serial mode, and has an access time of 10 microsec for ten digits. An eleventh channel contains a check digit to obviate errors. Each instruction, consisting of two 10-bit words, specifies an address and a function. Numbers, which are referred to by the address part of the instruction, are routed out to the computing elements, whose storage consists of electromagnetic delay lines operating serially at 1 Mc/s.

Computations on 10-bit numbers such as adding, subtracting and various logical operations, are completed in 60 microsec; this time includes reading the instruction. The main accumulator, also an electromagnetic delay-line memory, stores numbers in floating-point form, i.e. $X \cdot 2^Y$, where X is a 30-bit number and Y a 10-bit fixed-point exponent. All computations associated with this accumulator are automatic floating-point operations. Addition and subtraction take 180 microsec.

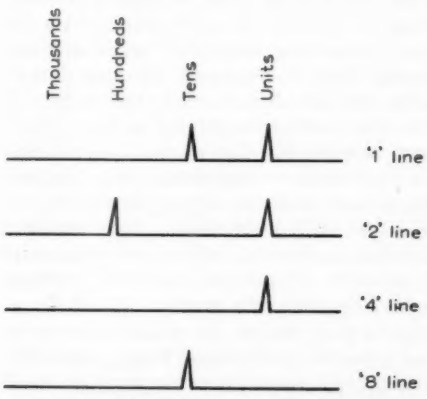
The multiplier is a 1 Mc/s series-parallel type, the final product being the sum of three partial products, each of which is the result of multiplying 10 bits of the multiplier by the whole of the multiplicand. A complete multiplication takes 300 microsec.

The machine, as shown in the Figure, is built into racks standing about 6 ft 6 inches high. Doors at the rear of the racks allow access to the valves and components. Magnetic drums are contained in the four separate cubicles on the right. On the control console can be seen a paper-tape reader and punch, which are the normal input and output mechanisms. 621.374.32:681.142.292

Acoustic-Delay-Line Calculator

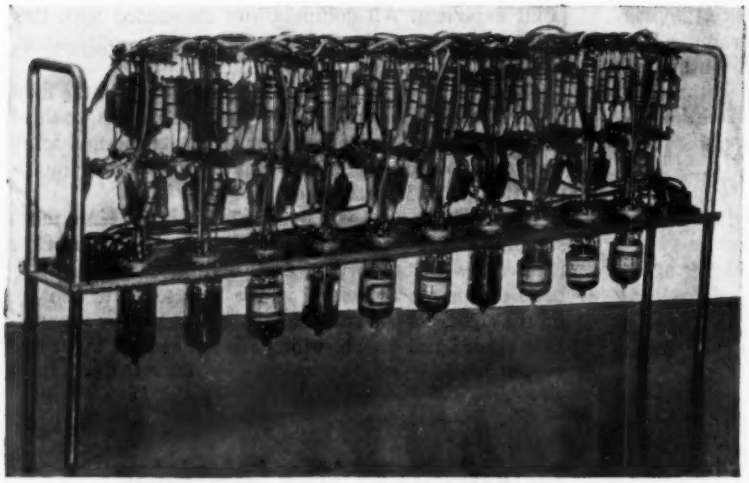
Paper No. 2093 entitled 'The Acoustic-Delay-Line Electronic Calculator', by J. A. Tempel, Graduate.

THE CALCULATOR HAS BEEN DESIGNED TO PERFORM ROUTINE arithmetic operations at a fast speed, and with a mini-



1 *Number 297 represented by pulse waveforms on four lines*

A Mercury installation



2 *Ten-valve chassis*

mum of programming. Its main applications lie in the field of business accountancy, although a modified model could be used for solving scientific problems.

The machine uses a form of binary decimal code, which enables the information to be retained in decimal and sterling scales of notation, thus dispensing with the need for elaborate input and output conversions. Each decimal or sterling digit is expressed by four binary digits presented in parallel on four lines, and coded '1', '2', '4', and '8'. This code is illustrated in Fig. 1 by a display of pulse waveforms, the number represented being 297. The four binary components of a digit are handled simultaneously and the digits themselves are operated upon sequentially commencing with the least significant ones. The sterling quantities are retained in their normal notation of pounds, tens of shillings, shillings, pence and decimals of a penny.

The calculator is programmed by means of a set of plugboards, the required instructions being preselected in the desired sequence by means of short plugs. Each plugboard possesses a multi-contact plug at the rear, so that programmes may be quickly altered by changing plugboards.

The calculator consists of four main parts; the input-output system, the store, the arithmetic unit and the control unit. Information to be operated on is transferred from a punched card through the input system to the store. It is then fed as required to the arithmetic unit, where the desired calculations are performed. The results are fed back to the store and then through the output system back to the card.

The input-output system consists of a standard 80-column card-reading-and-punching mechanism, which handles cards at a fixed rate of 100 a minute. The store has a capacity of 23 words, each word containing 10 digits. Long and short magnetostrictive delay lines are used as storage elements, the delay time of the former being seriously affected by variations of temperature. For this reason the pulse-repetition frequency of approximately 100 kc/s is automatically controlled to compensate for variations of delay time.

The calculator possesses self-checking facilities, which enable a thorough check to be made of the correctness of calculations performed, the machine being so programmed that two separate sets of calculations are carried out, which, if no faults are present in the machine, must give identical answers. If the answers differ from each other, the machine instantaneously stops calculating and a fault is indicated by the lighting of a lamp.

The electronic part of the machine is built up on racks, each rack containing about twenty chassis. Each chassis can hold ten valves, the components of each valve circuit being mounted on a separate turret, as shown in Fig. 2.

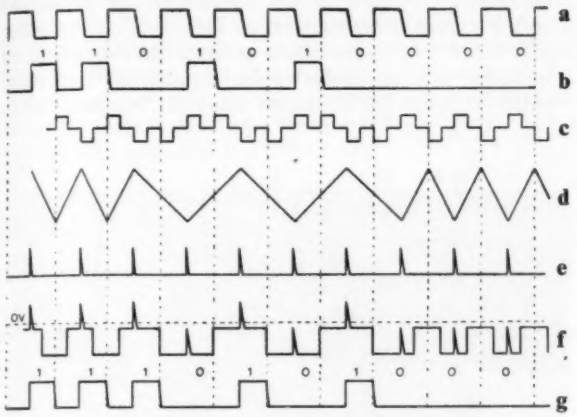
So far an experimental model of the calculator has been constructed, which has been running satisfactorily for a considerable length of time, while performing various test programmes. 621.374.32 : 681.142

An Interleaved-Digit Store

Paper No. 1999 entitled 'An Interleaved-Digit Magnetic-Drum Store for a Transistor Digital Computer', by J. H. Stephen, Ph.D., Graduate, and E. H. Cooke-Yarborough, M.A., Associate Member.

THE DESIGN OF THE ELECTRONIC CIRCUITS FOR THE interleaved-digit magnetic-drum store presented interesting problems, not only because transistors are used as the only active circuit elements but also because, for reasons given in another paper, the words on the magnetic drum are interleaved, each digit of a word being placed among the corresponding digits of several other words. The writing of the digits of one word onto the drum must not be allowed to disturb the adjacent digits of other words. This is best achieved by using a balanced writing waveform, so that to write a '1' a short current pulse in the writing head is closely followed by an equal pulse of opposite sign, the order of the pulses being reversed to write a '0', as shown in Fig. 1(*c*). This prevents the build-up in the heads, or in the transformers, of magnetizing currents which might persist after the writing pulses and affect the adjacent digits. Each pulse of a pair is about 5 microsec in duration, and there is a peak current in the writing head of about 150 mA. The point-contact transistors used for writing pass about 15 mA into the primary of the transformer, and are able to withstand voltage peaks of the order of 50 volts. The

signal read from the drum is amplified, limited and strobed as shown in Fig. 1.

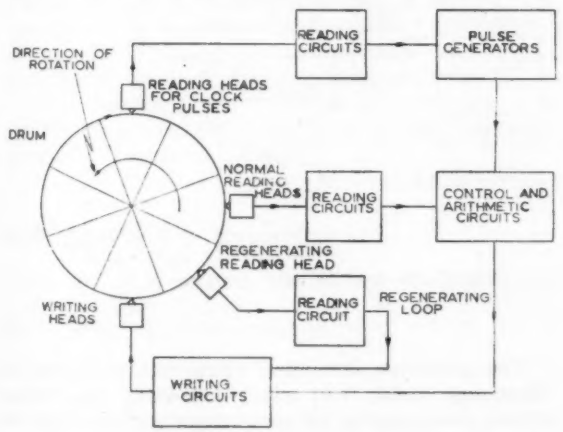


1 *Writing, reading and strobing waveforms*

(*a*) Timing waveform [minor pulse (*d*)].
(*b*) Input number.
(*c*) Writing current waveform.
(*d*) Reading waveform.
(*e*) Strobing pulses.
(*f*) Limited reading waveform with strobing pulses.
(*g*) Output number.

The magnetic drum is coated with iron oxide and the rather close packing of 180 digits to the inch is used. It would appear that the packing density is limited not so much by the characteristics of the magnetic surface as by the mechanical difficulty of positioning the heads with sufficient accuracy.

The general arrangement of the magnetic drum and associated circuits is shown in Fig. 2. Each track of the



2 *Block diagram of the magnetic drum and associated circuits*

drum is divided into eight sectors, each containing eight interleaved words. The operands used in an arithmetical operation may be on any track but must all be present in the same sector. The result of an operation is written two sectors away, and so is available at the reading head two sectors later to participate in a further operation, if necessary. When operands are in different sectors, one is first transferred to a special track, and the regenerative loop shown in Fig. 2 causes the contents of one sector to be repeated in every sector, so that the operand can be brought to the same sector as the other operand. By the use of interleaving, the regenerative loop can accommodate eight words. Three special tracks carry timing pulses which synchronize the rest of the computer, and the need for controlling the drum speed is thus avoided.

During development of the computer (i.e. for more than two years) a small drum with a useful capacity of about 200 words has been used. This has now been replaced by a larger drum with a working store of 426 words, backed by a larger store on the same drum with a capacity of 16 384 words, to which access is obtained by the use of relay switching and automatically movable heads.

621.374.32:621.318:681.142

A Digital-to-Analogue Convertor

Paper No. 2044 entitled 'A Rapid Digital-to-Analogue Convertor for Numbers having Eleven Binary Digits', by F. Beckett, Graduate.

IN SOME COMPUTERS AND DATA-PROCESSING DEVICES SOME inputs and outputs may be in analogue form, although the majority of the computing may be digital. In such devices a means is required for analogue-to-digital conversion and vice versa. The apparatus described in the paper accepts signals representing 11-digit binary numbers and generates a corresponding voltage analogue with a range −150 to +150 volts. The full digital accuracy of 1 part in 2048 is maintained except in the region +148 to +150 volts. The output voltage is available for at least 400 microsec within 700 microsec of the number being fed in. Resetting before the next cycle occupies a further 300 microsec.

At the beginning of each cycle an 11-stage binary counter is set to correspond with the binary number fed in. Pulses from a 3 Mc/s crystal-controlled pulse generator are then fed to the counter until it reaches maximum count, this condition automatically stopping the supply of further pulses. A time-base starts from +150 volts as the first pulse is fed to the counter and runs down towards −150 volts until it is stopped by the counter reaching maximum count. The time-base voltage at this stage represents the binary number on a scale where voltages of −150 volts and +150 volts represent zero and 2^{11} (2048) respectively.

The time-base rate is controlled by a diode comparator feeding an integrator negative-feedback control loop. The binary number zero is fed into every thirtieth cycle, and the comparator checks the output against a −150-volt reference supply.

The apparatus requires simple checking and adjust-

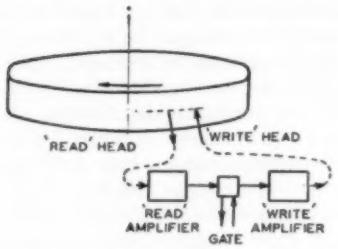
ment at weekly intervals. About sixty valve envelopes are used in the counter and time-base, and additional valves are required for functions such as the generation of pulses and control waveforms, and the provision of special power supplies. 621.374.32 : 681.142

Transistor Computers

Paper No. 2043 entitled 'A Transistor Digital Computer with a Magnetic-Drum Store', by T. Kilburn, M.A., Ph.D., D.Sc., Member, R. L. Grimsdale, M.Sc., Ph.D., Graduate, and D. C. Webb, B.Sc.

THE SMALL SIZE AND LOWER POWER CONSUMPTION OF THE transistor make its use in a digital computer particularly attractive.

The paper describes a transistor digital computer and its smaller prototype, which have been built at Manchester University. Both the machines are similar in principle although the full-scale machine has many additional features. The design of the machines is based on a magnetic drum as the only storage unit, the use of only one storage unit being simple and economical. Special registers to which immediate access is required are provided by regenerative tracks (Fig. 1). These tracks



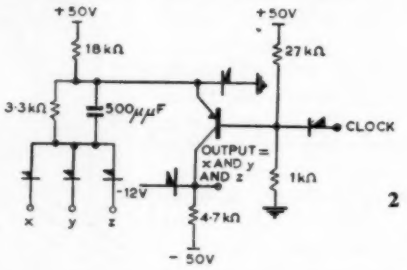
1 *Arrangement of regenerative track*

are arranged with the reading head mounted a short circumferential distance from the writing head in the direction of rotation. A signal recorded by the writing head at one instant will be reproduced by the reading head a short time later. By connecting the loop the system can be made to regenerate and operates as a store of the delay-line type.

In addition to storage, the magnetic drum provides the basic timing waveforms for the machine. The drum is driven by an induction motor and no attempt is made to control the speed. The operation of the machine is thus controlled by the drum speed, and the circuits have been designed to be insensitive to the normal speed variations of the drum.

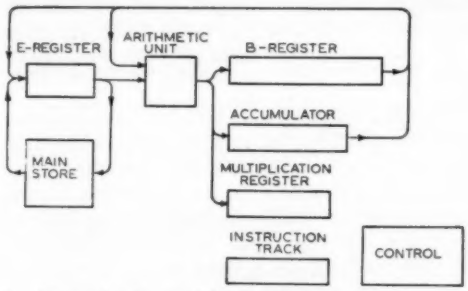
The pulse-repetition frequency, or clock frequency, is nominally 125 kc/s, a relatively high value, chosen to explore the potentialities of the point-contact transistor in computer circuits.

The circuits of the computer make full use of the special feature of the point-contact transistor—that it is possible to construct a two-state circuit with only one transistor. The arithmetical operations are performed with a logical adder-subtractor. This, and various other gate units use germanium point-contact-diode gates together with transistor pulse amplifiers. The pulse amplifier (Fig. 2) is turned on and 'bottoms' when



2 *Pulse amplifier with diode gate input*

positive input pulses occur on all three input leads. The transistor will remain on whether the input waveforms are present or not, because the emitter current can be supplied via the diode connected between emitter and earth. The circuit is reset to the off state (in which the collector is caught at −12 volts) by the regular clock waveform which raises the base above the emitter. A similar circuit is used as a staticizor (i.e. a single-digit store used to hold a controlling digit of an instruction), the output of which is used to control gates in the machine. A modified version of the two-state circuit is also used for the generation of the timing waveforms.



3 *General scheme of full-scale computer*

The prototype computer which was completed in November, 1953, had two single-word regenerative tracks, one used for the accumulator and the other for the instruction register. The general arrangement of the full-scale machine is shown in Fig. 3. The E and instruction registers are single-word regenerative tracks, the accumulator and multiplication registers are two-word regenerative tracks and the B register is an eight-word regenerative track. A pseudo two-address code is used specifying the address of the operand and the address of the next instruction. This arrangement makes possible

the reduction of waiting time by optimum programming. Provision is made to use the eight-word B register as a small rapid-access store to facilitate optimum programming. An automatic multiplier is also provided.

One hundred point-contact transistors were used in the prototype and two hundred in the full-scale computer, and an average of six point-contact diodes were used for every transistor. Each transistor circuit consumes approximately 0·75 watt.

4 *The transistor digital computer*

The magnetic-drum store can be seen in the foreground with four regenerative tracks mounted on the front.

A true assessment of the reliability of point-contact transistors in these computers is difficult because, first, the number used was small, and secondly, a large number of the transistors used were those which were supplied during 1953. Currently available point-contact transistors show a marked improvement in reliability and their performance in the high-speed pulse circuits is uniformly good from sample to sample.

621.374.32 : 621.395.625.3 : 621.314.7

C.P. Codes for Counting

Paper No. 1944 entitled 'The Use of Cyclic Permuted Codes in Relay Counting Circuits', by G. C. Tootill, M.A., M.Sc., Associate Member.

A GROUP OF DIGITS CAN BE REGARDED AS REPRESENTING a number by use of a radix of numeration, and this arranges the different possible groups in a natural sequence. In a cyclic permuted (c.p.) code sequence, however, an unnatural sequence of numbers is tolerated for the sake of the special property of consecutive groups of digits—that they always differ in only one digital place. Many different permutations of the natural sequence possess this property. The reflected binary c.p. code is the well-known one, and exists for any number of binary digits, four in Fig. 1(*a*). The c.p. code shown in Fig. 1(*b*), on the other hand, has the property that each digit has the same total number of changes.

a	b
0000	0000
0001	0001
0011	0011
0010	0010
0110	0110
0111	0111
0101	1111
0100	1011
1100	1001
1101	1101
1111	0101
1110	0100
1010	1100
1011	1110
1001	1010
1000	1000

1 *Cyclic permuted codes*

(*a*) Four-digit reflected binary c.p. code.
(*b*) C.P. code with four changes per column.

A counting circuit using electro-mechanical relays has a number of different states, each of which can be represented as a binary number. When a given digit has the value 0, this means that the corresponding relay is released, and when it has the value 1, the relay is operated. Some counting circuits use only a few of the possible different states, but the circuits described in the paper use all of them. Receipt of a pulse to be counted causes a transition to a new state of the relays. It is advantageous if this transition consists of the movement of one relay only, which means that the circuit must count in a c.p. code. Use of the reflected binary code results in a systematic circuit design. Use of the code shown in Fig. 1(*b*), on the other hand, results in longer life, since all four relays wear out together. 621.374.32: 621.318.5

Codes of Operation

Paper No. 2141 entitled 'The Classification and Design of Operation Codes for Automatic Computers', by K. D. Tocher, B.Sc., Ph.D.

THIS PAPER IS AN ATTEMPT TO RESOLVE THE CONFLICT between the demands of programmers of automatic computers for a wide range of facilities, and the limitations on complexity of control imposed by the engineers.

It is shown that the choice of a storage device for a computer determines the main structure of the machine and that the design problem must be solved for each type of machine separately.

Machines divide naturally into those which use a unified store for both numbers and instructions (which are coded as numbers) and those which use two separate stores. An analysis of the quantity of storage required for these two entities shows that any of the currently

available fast-storage devices are too expensive to provide all the storage required. A slower form of storage must be used to back the main store and this contributes considerably to the problems of the programmer.

If it were possible to provide a single store sufficiently large for instructions, the programmer's problems would be eased, but to achieve this economically some sacrifice of facilities in that store would have to be accepted. It is suggested that the ability to write into the instruction store is not a necessity and that if certain facilities are provided in the control of the machine its absence is not even an inconvenience.

A form of storage of this kind can be provided by cathode-ray-tube scanning of a punched card or photographic film, and the paper is mainly devoted to the design problems for a machine using such a non-erasable form of storage for instructions, with a conventional form of fast store for numbers, backed by another slower form of storage.

All the facilities of a machine with erasable-instruction storage can be provided if the machine has instructions which use the contents of number stores as part of the information specifying the instruction. For example, if the programmer wishes to specify a storage position varying on each execution of an instruction, he can achieve this by specifying a storage-position name which is interpreted by the machine to give the storage position, in terms of the contents of a special store. The contents of that store can be altered by arithmetic, and the form of the instruction remains invariant throughout the programme.

By studying the essentials of hand-computing methods a list of desirable features of a machine can be determined, while a comparison of the problems of automatic computing with those of desk computing reveals further desirable features. The latter are chiefly concerned with the automatic performance of organizational activities, corresponding in desk computing with starting new results on a fresh piece of paper, keeping track of the progress of the calculation, and so on.

It is shown how all the arithmetical features required can be organized in one simple pattern, which considerably reduces the difficulties of programming and of engineering, and how also the natural extension of this pattern will provide the other required facilities.

The whole paper is made explicit by describing the code of a projected machine under construction at Imperial College, University of London. 681.142

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* without being read at an Institution meeting which have not been described elsewhere in the *Journal*.

Electron Bombardment in Valves

A synopsis of a Measurement and Control Section paper (No. 2038) entitled 'Electron Bombardment of the Glass Envelope of a Receiving Valve', by G. H. Metson, M.C., Ph.D., M.Sc., B.Sc.(Eng.), Associate Member, and D. J. Sargent. The paper was published in May 1956, in Part B of the Proceedings.

THE PROBABLE CAUSES OF THE DEVELOPMENT OF STABLE bombarding potentials on the glass envelope of an oxide-cathode pentode are analysed and subjected to experiment. A photo-electric effect is examined in some detail and shown to give rise to dangerous potentials under certain conditions, which may be of interest to electronic switching engineers. 621.385.5.032.75

Source of Valve Noise

A synopsis of a Radio and Telecommunication Section paper (No. 2140) entitled 'Notes on a Source of Intermittent Noise in Oxide-Cathode Receiving Valves', by M. R. Child, Associate Member. The paper is published this month in Part B of the Proceedings.

A SOURCE OF INTERMITTENT NOISE IN OXIDE-CATHODE receiving valves is identified with the presence of variable leakage paths between certain electrodes. The dependence of this phenomenon on valve parameters is discussed, and mention is made of an improvement in valve design which inhibits the growth of inter-electrode leakage. 621.385.032.213

Servo-Operated Recording Instruments

A synopsis of a review of progress (paper No. 2131) with the above title by A. J. Maddock, D.Sc., F.Inst.P., Member. The paper is published this month in Part B of the Proceedings.

COMMENCING WITH THE FIRST SELF-BALANCING BRIDGE or potentiometer devised in 1897, a review is given, in historical form, of the several types of servo-operated recording instrument that have been devised since that date. These recorders are all of the type in which a correcting action takes place in the instrument itself, thus making available considerably more power for the recording stylus or pen than is available in direct-acting instruments. A more detailed discussion is then given of the principal types of modern instrument, classified according to the circuit component which is varied to produce balance, namely resistor or potentiometer, capacitor, electromagnetic device. Most instruments record against time as one of the variables, but function plotters, in which the relation between two variables other than time is plotted, are discussed, as also are scanning recorders devised for recording from a large number of input points. Several other special types are also included. 621.317.7.087.6

OBITUARY

FRANK AYTON

Frank Ayton, who died on the 24th January 1956, was born on the 10th January 1873. One of the great pioneers of the electrical industry, he obtained his early technical knowledge at the Finsbury Technical College, and his practical training with Siemens Brothers Ltd., of Woolwich. He took part in telegraph-cable laying in the Atlantic in 1894 and in the Amazon River in 1895. While still with Siemens, he supervised the equipment of the Waterloo and City railway and did much experimental work for the electrified section of the District underground line.

In 1898, Mr. Ayton went to Ipswich as Assistant Engineer in the firm of Kennedy and Jenkin, and five years later he was appointed Chief Engineer and Manager of the Ipswich Corporation lighting and tramway undertakings. During his period of office he did much to develop the tramway system in the town.

Mr. Ayton joined Ransomes, Sims and Jefferies Ltd., at Orwell Works, Ipswich, in 1921, as the Joint Managing Director and Works Director, and he held that position for nearly a quarter of a century. In this capacity he did a great deal of work for electric transport generally, particularly in the design and production of trolley-buses. He introduced these vehicles to the Ipswich streets and did much development work with battery-driven vehicles.

In 1913 he formed the Electric Vehicle Committee of Great Britain and became its first Honorary Secretary and eventually its Chairman. He edited the journal *Electric Vehicles*, which was issued by that committee.

He was a staunch supporter, and at one time President, of the Ipswich Engineering Society, and the younger generation of engineers owe a great deal to him for his lucidity, both in speech and in writing, in the consideration of engineering and electrical problems.

During the last war, he was a member of the Eastern Regional Board and dealt particularly with armaments; he was also the chairman of the Emergency Services Organization Panel for Suffolk, a member of the Council of the British Engineers' Association, President of the Incorporated Municipal Electrical Association, a member of the Grand Council of the Federation of British Industries and President of the executive committee of the Engineering and Allied Employers' East Anglian Association.

Mr. Ayton joined The Institution as an Associate in 1894, and was elected an Associate Member in 1899 and a Member in 1910. H. C. W.

GEOFFREY BOWERBANK

Geoffrey Bowerbank, B.SC., who died suddenly on the 13th February 1956, was born on the 7th July 1910.

Mr. Bowerbank was educated at the Royal Grammar School, Newcastle-upon-Tyne, and at St. Bees School, Cumberland. From 1927 to 1932 he was a Student Apprentice with C. A. Parsons and Co., taking the B.Sc. degree course in electrical engineering at Armstrong College, Durham University, and graduating in June 1932. After serving for a short period with C. A. Parsons and Co., he joined the North Eastern Electric Supply Co., Newcastle upon Tyne, and then in 1935 became Technical Assistant to the Constructional Engineer of the London Passenger Transport Board.

He joined the Admiralty Electrical Engineering Department as an Assistant Electrical Engineer in 1937, serving in the Royal Dockyards at Portsmouth and Chatham. He was promoted to Electrical Engineer in 1939, at Chatham, and in 1942 was appointed as Base Electrical Officer to the R.N. Base, Kilindini, East Africa, with the rank of Electrical Commander. He was responsible for carrying out the electrical installations in the base and its related establishments, which were being built up rapidly following the loss of Singapore, and for electrical installation and repair work in H.M. ships. He returned to England in 1945, on promotion to Superintending Electrical Engineer, and served in the headquarters of the Director of Dockyards and the Director of Electrical Engineering.

In 1949, following the recommendations of the Cooper Committee, an Admiralty Production Pool was formed and Mr. Bowerbank was selected as its Superintendent under the Deputy Controller (Production). When this latter post lapsed in 1951 Mr. Bowerbank became Superintendent of Production Services, responsible for administering over a thousand professional and technical officers throughout the United Kingdom. He was also responsible for advising the Board of Admiralty on the measures necessary for achieving the maximum degree of material standardization in all branches of the navy and he represented the Admiralty on the Joint Services Engineering Standards Co-ordinating Committee.

The sudden loss of such an experienced engineer possessing administrative ability of an exceptionally high order will be keenly felt in the Service. He is survived by his widow and two sons.

He joined The Institution as an Associate Member in 1939, and was elected a Member in 1952. He was also an Associate Member of The Institution of Mechanical Engineers. P. S.

ALFRED WILSON CLEGG

Alfred Wilson Clegg, who died on the 11th February 1956, was born on the 23rd May 1878. He was educated at Burnley Grammar School and articled to the old-established firm of Simpson Bros., electrical and mechanical engineers, of Hapton, Lancashire, and during his four-year apprenticeship he attended part-time courses at Blackburn Technical College.

He joined the Accrington Corporation electricity undertaking as a Junior Assistant in 1900—the year in which electricity supply began there—being promoted a year later to Deputy Electrical Engineer, and in 1914 to Engineer and Manager, which position he held until his retirement in 1941. During this long period of service he witnessed many changes. The total energy sold by the undertaking rose from 98000 kWh to over 82 000 000 kWh per annum. The power station was reconstructed, and the gas engines and steam reciprocating sets of about 4 500 kW total capacity were replaced by steam turbines of 23 750 kW capacity.

Mr. Clegg was very successful in the development of industrial drives by electricity and was responsible for the electrification of many cotton mills, brickworks, collieries

and engineering works. He also developed the use of electricity on farms, and before his retirement he had laid electricity supplies to most of the farms in his area. Often when the distance was fairly great he agreed that the farmer should do the trenching, and the reinstatement after the cables were laid and tiled, in order to keep extra charges at a minimum.

He was very keen on low generation and distribution costs, and was very proud of his low tariff, which incidentally was the means of the conversion of all the street lighting in the town of Accrington from gas to electricity. His slogan was 'Cheap electricity needs no advertisement'.

Mr. Clegg joined The Institution as an Associate Member in 1911, and was elected a Member in 1936. A. G.

FREDERICK ARTHUR COLLINS

Frederick Arthur Collins, who died on the 7th March 1956, was born on the 1st December 1903. He was educated at East Hove Higher Grade School and at Varndean School, Brighton, and in 1919 started his electrical engineering career with Allen West and Co., Brighton, with whom he stayed until 1925, when he joined the Post Office Engineering Department. While with the Post Office he studied telephony and telegraphy through evening classes at Brighton Technical College, gaining first-class final certificates in all his subjects at the City and Guilds examination.

In 1930 Mr. Collins was seconded to the Post and Telegraph Engineering Department, Southern Rhodesia, where he eventually attained the position of Engineer, and in 1945 he was appointed Divisional Engineer, Matabeleland, at Bulawayo. In 1946 he was appointed to the Chief Engineer's headquarters staff at Salisbury, later becoming Assistant Chief Engineer, which post he held until the time of his death.

Mr. Collins's pursuits were mainly scientific, although he was also fond of music and in recent years took up the clarinet. He was interested in the high-fidelity reproduction of classical music, and spent much of his spare time experimenting along quite original lines. He was not gregarious but those who were privileged to know him well appreciated his sterling qualities. He had an outstanding insistence on justice and fair play, and an equally deep reluctance to criticize others, even in jest. He leaves a widow and one son.

He joined The Institution as an Associate in 1945, and was elected an Associate Member in 1945 also and a Member in 1954. G. J. A.

ALEXANDER CHARLES CRAMB

Alexander Charles Cramb, who died on the 10th February 1956, was born at Melton Constable, Norfolk, in 1874. Educated at Truro Collegiate School and Devon County School, he spent the whole of his long and successful career in the electricity supply industry, occupying posts at Holloway, Islington, Huddersfield and Hampstead in the very early days of municipal electricity undertakings. It was at Croydon, however, where the foundations of his great reputation were laid. He joined Croydon Corporation as Chief Assistant Engineer in 1902. Two years later he became Chief Engineer and Manager, a post which he held with distinction until 1931. Under his direction the undertaking expanded and prospered considerably. After the First World War Mr. Cramb embarked upon a programme of domestic electrical development. New three-phase 50 c/s generating plant was installed at Factory Lane replacing the old single-phase 60 c/s supply; domestic and commercial two-part tariffs were inaugurated, and a hire scheme for domestic appliances was begun. He was one of the first to appreciate the advantages of the electric water-heating load and to encourage its growth. During his stay at Croydon Mr. Cramb played a considerable part in the development of the Incorporated Municipal Electrical Association. He was President of the Association in 1916–17 and after a brief period as Honorary Treasurer he undertook the duties of Honorary Secretary, a position which he held from 1919 to 1931. He organized many of the successful conventions of the I.M.E.A. during that time—annual events which were always high-lights of the year's happenings. He was also chosen by the Electricity Commission in 1925 to serve on committees dealing with domestic electricity supplies, and in 1930 to be Chairman of a committee dealing with tariffs.

Mr. Cramb's connection with the Electrical Development Association dated from its earliest days. He was one of the original members of its council and was Chairman in 1928. In 1931 he followed Lt.-Col. W. A. Vignoles as Director and Secretary, a post which he held until his retirement in 1943, and in which he brought his great knowledge of electricity supply to bear upon the problems of development, thereby increasing by no small amount the Association's national prestige and influence.

A man of wide interests, Mr. Cramb was a founder member and a Past-President of the Association of Public Lighting Engineers and served on the councils of the British Standards Institution and the Electrical Research Association. Justice and humanity were outstanding traits of his character; he never forgot an old friend or a former member of his staff.

Mr. Cramb joined The Institution as an Associate in 1901, and was elected an Associate Member in 1902 and a Member in 1908. He was a Member of Council from 1926 to 1929. He was also a Member of The Institution of Mechanical Engineers. V. W. D.

ALFRED EDWARD FARROW

Alfred Edward Farrow, who died on the 3rd March 195[illegible] was born in the eighteen-sixties. He was educated at [illegible] Board School of Rockland St. Mary, Norfolk, and received his practical training with R. Beeton and Co., agricultural engineers of Norwich, as Assistant to Mr. W. H. Miller, working on the installation of electrical plant from 1884 to 1887, and in the workshops of T. Walker and Co., contractors on the Manchester Ship Canal.

In 1891 he became Assistant Engineer to the Windsor and Eton Electric Supply Co., for whom he installed steam plant of 25 kW capacity. The following year he joined Roger Dawson Ltd., of Windsor, as District Engineer, and during his two years with that firm he installed about 40 private electric plants in and around Windsor. In 1895, with Sir William Shipley (one time mayor of Windsor) he started the Windsor Electrical Installation Co., of which he became Chief Engineer. In this capacity he helped to supervise the laying of mains and the installation of lighting plant for the supply of electricity and street lighting in Windsor and Eton. The power station was originally equipped with Peache steam engines, generating direct current. Later it was equipped also with Diesel generators, and provided a single-phase a.c. supply to outlying areas. Mr. Farrow became Consulting and Resident Engineer of the company, and in 1902 he extended

his field of work to embrace the general managership of the Slough and Datchet Electric Supply Co., which he started in collaboration with the same directorate. The power station for this area was equipped with Diesel engines and a Uniflow steam engine.

When the electricity works were taken over by the Metropolitan Electric Supply Co., Farrow turned his abounding energy to buying up small electricity works, putting money and knowledge into running them, and then selling them to the financial concerns who were at that time beginning to extend their tentacles into the supply industry. Finally, having exhausted this field of business, he retired to Cranleigh, where his son was carrying on an electrical business, and did a certain amount of consulting work.

Alfred Farrow was a man of original mind and overflowing energy. In collaboration with Mr. F. A. Greene he built a very early electric motor car, a petrol car, and finally a petrol-electric car. The last was destroyed in a fire and nothing further was done with it, but the first two cars ran for some time. He was one of the pioneers of Diesel generation, and was an early member of the Diesel Engine Users' Association, of which in 1923 he was elected President. He was a man of wide interests, ever ready with advice and assistance. His friends will always miss him.

Mr. Farrow joined The Institution as an Associate Member in 1899, and was elected a Member in 1924.

ROBERT WILLIAM LESLIE HARRIS

Robert William Leslie Harris, B.SC., who died on the 27th January 1956, was born on the 28th August 1908. He was educated at the Royal Grammar School, Newcastle upon Tyne, and at Armstrong College, Durham, where he obtained his degree. He served his apprenticeship with A. Reyrolle and Co., and in 1930 was appointed Contract Engineer on their staff. He stayed with them for a further ten years during which time he became personal assistant to the late Mr. H. W. Clothier. His work during these years concerned various aspects of electric power generation and transmission. Mr. Harris joined the staff of Kennedy and Donkin in 1940 and was responsible for work on the Central Electricity Board's 132 kV and lower-voltage substations. He was also concerned with work for the Government of Northern Ireland on their 110 kV transmission system. During the war years he was responsible for electrical installations in certain emergency underground factories for the Ministry of Aircraft Production and for the Ministry of Supply.

In 1945 Mr. Harris accepted an appointment as the first Registrar of the newly formed Professional Engineers Appointments Bureau and he remained in office until early 1950. During this period he had the difficult task of overcoming all the teething troubles which inevitably face any new organization, and at the same time of coping with the large number of professional engineers trying to re-establish themselves in civilian life. His advice was sought and readily given on a very wide range of problems.

In 1950 Harris joined the staff of Messrs. Preece, Cardew and Rider, where he progressively relieved Mr. H. J. London of the routine work in connection with the Central Electricity Authority's East Yelland station, until, during the latter's absence in New Zealand in 1952, he took over full control of that station. He was also concerned in works abroad and in 1951 he visited Saudi Arabia in connection with a number of Diesel stations, including that being built to supply Mecca.

His legal training and orderly mind gave him the right approach to matters of valuation and arbitration, and he visited Mauritius in 1952 and 1953 to advise the newly formed Central Electricity Board on the acquisition of company undertakings in that island. In the latter year he also spent some time in Cyprus on similar work for the Electricity Authority of Cyprus.

He was closely concerned with a valuation of the Baghdad Light and Power Co., before that company was nationalized by the Iraqi Government, although he never actually visited the country.

Before illness drove him from the office, he was turning his attention to electrical equipment required for a new thermal station for the New Zealand State Hydro-Department.

Mr. Harris joined The Institution as a Graduate in 1930, and was elected an Associate Member in 1935 and a Member in 1943. He served as Honorary Secretary of the North-Eastern Students' Section in 1932–33. He was also a Member of The Institutions of Civil and of Mechanical Engineers.

B. D.; J. M.; J. F. ST.G. S.

ROBERT ILLINGWORTH

Robert Illingworth, O.B.E., who died on the 9th March 1956, was born on the 31st October 1888. He was educated at Thames Road Council School, Blackpool, and apprenticed in 1901 to Blackpool, St. Annes, and Lytham Tramway Co., continuing his studies during the evenings at Blackpool Secondary School. He worked for Middleton Electric Traction Co., as an improver, for one year until 1907, when he joined Oldham Corporation's electricity department. He took evening classes in electricity and magnetism from 1907 to 1912 and on the completion of his course he was appointed Charge Engineer in Middleton Corporation's electricity department. After occupying similar positions at Accrington and Mansfield, he joined Palmers Shipbuilding and Iron Co., Jarrow, in 1918, as Engineer-in-Charge, and stayed with that company for five years. He was then appointed Chief Electrical Engineer at Cory Bros. and Co., Cardiff, and seven years later joined the Plymouth City Council's electricity department as Deputy Chief Electrical Engineer. He served in this capacity for three years and then went to Poplar Borough Council as Deputy Chief Engineer and Manager, being appointed Chief Engineer and General Manager a year later.

At Poplar he was the initiator of several major developments, of which the Brunswick Wharf generation station is particularly noteworthy. For his service in the Home Guard and his activity in the protection of his installation and maintenance of supply during heavy air raids, he was made an O.B.E. in 1942.

On the nationalization of the electrical supply industry he was appointed Generation Engineer (Construction) for the London Division, a position which he held until his retirement in 1955, and he was thus able to see the completion of the project which he had conceived and planned.

He took much interest throughout his life in inventions, and was personally responsible for a design of a built-in kitchen cabinet for the large building programme undertaken by public authorities after the war.

He was a keen gardener, and very fond of motoring. Although full of energy most of his life, he showed consideration for those of his colleagues and staff who were not so blessed, and he will be remembered by a large circle of friends as one who lived mainly for the welfare of those around him.

Mr. Illingworth joined The Institution as an Associate Member in 1919, and was elected a Member in 1935. He served on the Western Centre Committee from 1929 to 1932. He was also a Member of The Institution of Mechanical Engineers. C. F. F.

GEORGE LINGARD KIRK

George Lingard Kirk, who died on the 6th June 1955, was born on the 23rd January 1884. He received his general education at Loughborough Grammar School, and his engineering education in day courses at Nottingham University College. Thereafter he followed a three-year pupilage with the Brush Electrical Engineering Co., and subsequently served for two years on the engineering staff of the Bournemouth and Poole Electricity Supply Co. at Bournemouth.

In 1905 he took up his first oversea appointment as Assistant Engineer and Mains Superintendent to the Bombay Electric Power and Traction Co., resigning in 1907 to become the Resident Engineer of Callender's Cable and Construction Co. in Rangoon, where he carried through an important cable contract.

Returning to England in 1908, he successively filled appointments with supply companies in Sheerness and Southport and with the Newcastle Graphite Co.

In 1922 he again went abroad, as Sales Engineer in Bombay for the General Electric Co. (India) Ltd. For ten years, until 1938, he served as Chief Power Station Superintendent to the Department of Government Electrical Undertakings, Ceylon, and in the following year he was appointed Senior Electrical Engineer in the Public Works Department, Nigeria. Ill health caused him to relinquish his duties in the autumn of 1940, and he was invalided from the Colonial Service in May, 1942.

With improvement in his health, his active nature led him to seek further occupation, and he joined The Institution staff in 1944 as a member of the Technical Department serving on a number of technical committees concerned with aircraft electrical safety regulations, Codes of Practice and the like.

In 1946 he resigned and returned to Ceylon, partly for reasons of health and partly for reasons of sentiment. There he took up an appointment with Messrs. Boustead Bros., managers of the Colombo tramways, and eventually became Manager. When the tramways were taken over by the Colombo Municipality, Mr. Kirk joined Hoares (Ceylon) Ltd., at their Colombo Engineering Works, whom he served in the capacity of Deputy Chief Engineer, eventually becoming a Director, which office he held for a few years, from 1949.

During this time he was concerned with the successful execution of a variety of electrical engineering contracts, including the establishment of a power station and a complete urban and rural electrification scheme for the Gal Oya Development Board, an important irrigation and settlement project in a remote area to the east of Ceylon. Apart from Mr. Kirk's experience as an electrical engineer he was also a very capable mechanical engineer, being principally concerned with large Diesel engines.

He finally returned to England in 1953 and settled with his wife (who survives him) first in Dorset and then in Hampshire.

Mr. Kirk joined The Institution as an Associate Member in 1912, and was elected a Member in 1923. During his first period in Ceylon he played a considerable part in the setting up of the Ceylon Local Committee (now the Ceylon Oversea Branch) of The Institution, of which he served as the first Honorary Secretary from 1935 until he left for Nigeria at the end of 1938. H. J. H.

CLIFFORD LAKIN-SMITH

Clifford Lakin-Smith, who died on the 17th August 1955, was born on the 2nd December 1878. He was educated at Shrewsbury School and received practical training as an apprentice at the firm of Belliss and Morcom, Birmingham, from 1895 to 1899, during which time he took a two-year course at Birmingham University. He was then appointed Assistant Engineer at the Winchester Electric Light and Power Co., and two years later joined the Midland Machinery Co. as Manager and Director. From 1903 to 1907 he was employed by Dorking (Surrey) Lighting as Engineer and Manager, and then took up a post as Resident Engineer, Manager and Secretary to the Guernsey Electric Light and Power Co.

In 1913 he entered in business on his own account as Managing Director of New Rotoplunge Pump Co. at Victoria, London, where he remained until he was forced to retire owing to ill health several years ago.

In his private life Mr. Lakin-Smith took a keen interest in local affairs and was for some time Chairman of the Commissioners of Income-Tax at Stratford-on-Avon. He also founded and organized the sub-committee of the Friends of St. David's Cathedral, Wales. He is survived by his widow and two sons.

Mr. Lakin-Smith joined The Institution as an Associate in 1902, and was elected an Associate Member in 1904 and a Member in 1909. He was also a Member of The Institution of Mechanical Engineers.

ALFRED DONALD NEWBURY

Alfred Donald Newbury, who died on the 5th March 1956, was born on the 20th November 1892. He received his early education at Christchurch School, Ilford, and Essex County High School, Ilford, and his technical education at West Ham Technical College. After obtaining a wide practical experience with Stepney Electricity Department, West Ham Corporation Electricity Department and Charing Cross, West End, and City Electricity Supply Co. from 1910 to 1914, he was appointed Resident Engineer to Knowles Oxygen Co. at Bromborough, Cheshire.

During the First World War he joined the R.N.V.R. and was afterwards transferred to the R.A.F., serving as an Officer in the Airship Section. In 1923 he joined C. P. Sparks and Partners, consulting engineers of London, but left them in 1925 on being appointed Chief Assistant Engineer to the Notting Hill Electric Lighting Co. He held this position till 1937, when, on the company being taken over by the Metropolitan Electric Supply Co., he retired temporarily from engineering work.

During the Second World War he was employed by the Ministries of Works and Planning and of Fuel and Power as a supervising engineer responsible for mechanical and electrical work in connection with Royal Ordnance Factories, coal stocking plants, etc. In 1946 he joined Henry Pooley, consulting engineer of London, handling mechanical and electrical work in connection with large cement works at home and abroad, until his final retirement in 1953, due to failing health.

Mr. Newbury was a versatile engineer who was held in high esteem by his colleagues and respected by all for his qualities of sincerity and integrity. He is survived by his widow.

He joined The Institution as an Associate Member in 1917, and was elected a Member in 1943. C. D. K.

PERCY ROSS STEVENSON

Percy Ross Stevenson, who died on the 7th February 1956, was born on the 14th May 1882. He was educated at Glasgow High School and received his engineering education at the Royal Technical College, Glasgow, where he was a first prizeman in senior electrical engineering. He gained practical experience with the firm of Henry Burrell at Glasgow, and then in 1901 became Private Assistant to Professor Magnus Maclean, of Glasgow, in which capacity he did work on magnetic induction and on the oscillograph.

He moved to Manchester in 1903, as Draughtsman to Matthews and Yates Ltd., where he was engaged on the design of electric motors, and the following year he became the company's Manager for Scotland.

In 1908 he left this firm to join his brother Mr. J. Ross Stevenson as a partner in the firm of J. Ross Stevenson and Co., of Edinburgh. The firm specialized in the electrification of country houses, installing complete equipment of generating plant, storage plant and wiring, and established a considerable reputation in this sphere. The firm ceased business in 1952, when both partners retired.

A confirmed bachelor and a clubman of the old type, Mr. Stevenson was a familiar figure in Edinburgh, where his dignified presence and engaging humour made him widely known and respected. He was considered to be one of the foremost authorities on the life and work of Sir Walter Scott, for whom he had a lifelong admiration, and much of his spare time was devoted to research into Scott's life and writings.

Mr. Stevenson joined The Institution as an Associate in 1904, and was elected an Associate Member in 1907 and a Member in 1937. W. D. D.

FRANCIS STANLEY WAINSCOT

Francis Stanley Wainscot, who died on the 12th November 1955, was born on the 16th October 1889.

Many of the older generation of Royal Air Force Officers, particularly those now in the Technical Branch, will regret the passing of 'Willie' Wainscot, as he was known to his close friends. After his education at St. Helen's College, Southsea, his early career was spent in the National Telephone Co., Portsmouth, and naturally enough he joined the Royal Engineers during the First World War. Because of his experience in communication he was one of the few non-flying men granted a commission in the newly formed Royal Air Force. Indeed he was one of a small band of officers who were in effect the precursor of the present-day Technical Branch. Though he served in India for five years as a signals officer, his main activity in the Service was in the training field. He retired in 1936 but carried on his instructional work as a civilian technical officer at Cranwell. He was mobilized in 1939 and continued to be employed on the urgent task of training electrical personnel to service the increasing amount of electrical equipment of war-time aircraft. He was a keen and active freemason. His only son has also taken up the profession of electrical engineering.

Sqdn.-Ldr. Wainscot will be sadly missed by his family and his friends.

He joined The Institution as an Associate Member in 1937, and was elected a Member in 1943. W. T. M.

PERCY WICKS

Percy Wicks, B.SC., who died at his home at Enfield on the 26th February 1956, was born near Stroud on the 2nd May 1889. He was educated at Banbury County School and Cheltenham Training College. After graduation in 1915 he joined the London Electrical Engineers, later transferring to the Royal Engineers and becoming responsible for electrical equipment in searchlight stations. In 1919 he joined the Edison Swan Electric Co. at Ponders End, where he was engaged in lamp research. After two years he left industry to join the staff of the Walthamstow Technical Institute as a Lecturer in Physics. He moved a year later to become Head of the Electrical Engineering Department at Enfield Technical School, which at that time was small; he initiated and developed evening courses for the National Certificate and for the City and Guilds examinations in electrical subjects.

During the Second World War the school was transferred to a new building, and became known as the Enfield Technical College. Here Mr. Wicks was in charge of many hundreds of Service trainees and officer cadets, and in this period part-time day classes for the National Certificate and Intermediate B.Sc. examinations were started. Under his guidance the Electrical Engineering Department became so large that when he retired at Christmas, 1953, it was necessary to divide it into two. Mr. Wicks found complete retirement too irksome, and returned as a part-time teacher for a few half-days each week. His sudden death came as a profound shock to his colleagues and to many of the thousands of students who passed through his hands.

Mr. Wicks joined The Institution as a Graduate in 1924, and was elected an Associate Member in 1925 and a Member in 1943. P. D.

LOUIS BONIFACE WILMOT

Louis Boniface Wilmot, who died on the 8th December 1955, was born on the 5th June 1877, at Port Elizabeth, South Africa. He was educated at St. Aidan's College, Grahamstown, and Katwijk College, Holland, and received his practical training with Witwatersrand Deep Ltd., and with the General Electric Co., Salford. During his two years in Salford he attended evening classes at the Royal Technical College, and in the following year took a full-time course at Owens College, Manchester.

Mr. Wilmot served in the 105th Imperial Yeomanry in the South African War, after which he returned to the Witwatersrand Deep gold mine until 1908, when he joined the British Westinghouse Electrical Co. in Johannesburg.

He resumed his direct association with gold mining the following year and served in turn with the Randfontein Estates Gold Mine Co., Consolidated Mine Selection, S. Neumann and Co., and the Central Mining and Investment Corporation, before taking up private practice as a consulting engineer in 1920.

In 1926 he entered the service of the Anglo American Corporation of Northern Rhodesia, but returned to private practice in 1935. Later he joined G. H. Langler and Co. in Johannesburg, but in 1937 he reverted once more to his private practice and continued in it to the time of his death. Since 1938 he had been adviser to the patents department of the Chamber of Mines in Johannesburg.

Mr. Wilmot joined The Institution as an Associate in 1903, and was elected a Member in 1911.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

ANSTEY, E., and MERCER, E. O. 331

Interviewing for the Selection of Staff*

London, Allen and Unwin for the Royal Institute of Public Administration, 1956. pp. xiv, 111. 21 × 14 cm. 10s. 6d.

Although written mainly for those who only occasionally have to interview candidates, there is much that will interest those who have to spend much of their time doing so, and candidates who may be submitting themselves for interviews. It discusses the purpose of an interview, the way it should be conducted, and appraisal of the information obtained.

ARSCHINOW, S. S. 621.396.615

Frequenzkonstanz von Rohrengeneratoren. (The frequency stability of valve oscillators)

Berlin, VEB Verlag Technik, 1955. pp. 260. 21 × 15 cm. £2 approx.

ASHLEY, R. 658

Electrical Estimating*

2nd ed. New York, McGraw-Hill, 1956. pp. viii, 363. 26 × 17 cm. £3.

Explains in great detail the tools and methods used in estimating and the tools and methods used by contractors. It goes into considerable detail and includes many illustrations and examples, with tables, schedules and forms. The book relates to American labour and practice.

BERTIN, L. 539

Atom Harvest*

London, Secker & Warburg, 1955. pp. 253. 22 × 14 cm. 20s.

This is a most interesting book. It puts in the right perspective the importance of the contribution made by British scientists in the development of the atomic bomb, and the subsequent British work on the hydrogen bomb and on peaceful developments. The story is an absorbing one which can be followed easily by the layman.

BURDA, E. J. (Editor) 620.9

Applied Solar Energy Research. A directory of world activity and bibliography of significant literature

Stanford, California, Stanford Research Institute, 1955. pp. ix, 298. 22 × 14 cm. £2 5s.

Six thousand references some of which include a short abstract. The indexing arrangement consists of listing the number of each appropriate reference under a few alphabetically arranged catchwords.

CANNING, R. G. 518.5

Electronic Data Processing for Business and Industry*

New York, Wiley; London, Chapman and Hall, 1956. pp. xi, 332. £2 16s.

Intended to make management aware of the possibilities of digital data processing machines for business clerical functions. It does not describe the machines, only applications of them, several examples being described in detail. This book will be reviewed in a future issue.

CENTRAL REDIFFUSION SERVICES LTD. 654.19

Commercial Broadcasting in the West Indies

London, Butterworths Scientific Publications, 1956. pp. xii, 91. 22 × 15 cm. 5s.

This interesting little book gives a brief outline of the standard of living about the time of the introduction of broadcasting in 1935. It describes the kind of programmes which have been developed from small beginnings and their importance as a part of the education of a largely illiterate population. The technical developments in radio and wire broadcasting, mainly since the war, using short-wave and later medium-wave transmission are described.

COHEN, A. B. 621.395.623.7

Hi-Fi Loudspeakers and Enclosures

New York, Rider, 1956. pp. vii, 360. 22 × 14 cm. 38s. approx.

Deals with various types of loudspeaker and modifications of design to improve their response characteristics, the use of more than one loudspeaker and suitable networks. Discusses baffles, horns and enclosures, and finally the part played by room acoustics.

DUNSHEATH, P. (Editor) 001.8

Industrial Research, 1956–1957

3rd ed. London, Todd, 1956. pp. 444. 22 × 15 cm. £3 3s.

A reference book of the activities and personnel of industrial research organizations, government and private. It contains also notes on careers in industry, of university courses in pure and applied science and the qualifications necessary for membership of professional institutions. An entirely new section covers the whole of the activities of the U.K. Atomic Energy Authority.

EINSTEIN, A. 50

Essays in Science

Abridged ed. New York, Philosophical Library, n.d. pp. xi, 114. 17 × 11 cm. 22s. approx.

An abridged edition, translated from the German of 'The World as I see it', in which Einstein's writings on religion, politics, etc., have been omitted. The subjects covered include research, scientific truth, theoretical physics and relativity.

FAUGERAS, D. 621.394

Appareils et Installations Télégraphiques. (Telegraphic apparatus and installations)

Paris, Éditions Eyrolles, 1955. pp. 562. 24 × 16 cm. £4 approx.

FELDTKELLER, R., and ZWICKER, E. 534.7

Das Ohr als Nachrichtenempfänger. (The ear as a communication receiver)

Stuttgart, S. Hirzel Verlag, 1956. pp. 89. 24 × 16 cm. 24s. approx.

Discusses the characteristics of the human ear in terms of distortion, etc., met with in a communication system.

FISCHER, F. A. 621.395.61

Fundamentals of Electroacoustics

London, Interscience Publishers, 1955. pp. xii, 186. 22 × 14 cm. £2 5s.

This is a mathematical treatment of the subject and the reader is expected to have some familiarity with the differential and integral calculus and with the general theory of oscillations. Electric and mechanical oscillators and the conversion of electrical into mechanical energy are first considered. The remaining chapters deal with transducers.

FRANCIA, G. T. di 538.56

Electromagnetic Waves

London, Interscience Publishers, 1953. pp. xiii, 320. 23 × 16 cm. £2 5s.

The opening chapter is for students who need to extend their grasp of the mathematics employed in the book. This is followed by a chapter on the Giorgi system of units. The electromagnetic field is then discussed in general terms before electric circuits. Transmission lines and waveguides are considered.

GRAHAM, K. C. 621.315.3

Interior Electric Wiring and Estimating. Part Two. Industrial

Chicago, American Technical Society; London, Technical Press, 1955. pp. ix, 324. 22 × 14 cm. 36s.

The second of two volumes into which this work has been expanded. It deals with wiring for machines, transformers, power distribution, and the requirements of special industrial equipment such as X-ray apparatus and welding equipment. There is a chapter on estimating.

For Part One of this work see UHL, A., and others.

HENNEY, K., and others (Editors) 621.385

Reliability Factors for Ground Electronic Equipment*

New York and London, McGraw-Hill, 1956. pp. 286. 29 × 22 cm. £2 16s. 6d.

The authorities were concerned that much of the material supplied to American ground forces proved unserviceable or failed at a critical time and they organized an investigation. This book, which is based on the results which have been obtained, indicates the causes of unreliability, and the method of assessing the probable reliability of equipment.

KAUFMAN, M., and THOMAS, H. E. 621.397.3

Introduction to Color TV

2nd ed. New York, Rider, 1956. pp. iv, 156. 22 × 14 cm. 24s. approx.

A simple description of the principles of the system of colour television approved by the National Television System Committee. The method of operation of tricolour picture tubes is explained, and detailed receiver circuit design is illustrated by descriptions of two commercial receivers. In this edition larger screen tubes using magnetic convergence principles and simplified receiver circuits are described.

MACLANACHAN, W. (Editor) 621.39(03)

Television and Radar Encyclopaedia

2nd ed. London, Newnes, 1955. pp. viii, 216. 22 × 14 cm. 30s.

A reference book of television and radar terms in common use in this country and the United States. The definitions or descriptions, which are arranged alphabetically, are technical but simple, varying in length from a sentence, or more commonly a paragraph, to half a page. They include contributions by acknowledged authorities. Illustrations and diagrams are used extensively throughout.

MITRA, S. K. 551.51

The Upper Atmosphere

2nd ed. Calcutta, The Asiatic Society, 1952. pp. xxiv, 713. 26 × 17 cm. £4 5s.

The object of this book is to give an account of the present state of knowledge of the upper atmosphere obtained by direct and indirect observations. Of particular interest to members will be the discussion of radio propagation in the ionosphere, electrical currents in the upper atmosphere, magnetic disturbances, the auroras and rocket exploration.

OLDENBURGER, R. (Editor) 621–52

Frequency Response*

New York, Macmillan, 1956. pp. xii, 372. 29 × 21 cm. £2 12s. 6d.

Papers presented at the 1953 American Society of Mechanical Engineers Frequency Response Symposium. Papers dealing with the fundamentals of the subjects are followed by those covering a wide field of control applications.

ROLLER, D., and ROLLER, D. H. D. 93 : 537

The Development of the Concept of Electric Charge. Electricity from the Greeks to Coulomb

Cambridge, Harvard University Press, 1954. pp. 97. 23 × 15 cm. 16s.

A most interesting little historical account with a useful bibliography.

SCHURE, A. (Editor) 621.396.615

Multivibrators

New York, Rider, 1956. pp. 48. 22 × 14 cm. 7s. 6d. approx.

A non-mathematical description of the basic principles of the bi-stable, mono-stable and a-stable multivibrator. Waveform and circuit diagrams are given together with values of components and characteristics.

SEELEMANN, F. 621.396.82

Funk Entstörung. (Radio interference suppression)

Darmstadt, Otto Elsner Verlagsgesellschaft, 1954. pp. xxx, 798. 21 × 15 cm. £4 18s. approx.

This book will be reviewed in a future issue.

SKRODER, C. E., and HELM, M. S. 621.3.001.4

Circuit Analysis by Laboratory Methods

2nd ed. Englewood Cliffs, N.J., Prentice-Hall, 1955. pp. xvi, 376. 24 × 16 cm. £3 1s. 6d.

Gives a wide range of laboratory experiments presented as problems, together with the related circuit theory and laws. Covers d.c. and a.c. circuits, non-sinusoidal periodic waves, filters, coupled circuits and network theorems.

SKROTZKI, B. G. A. (Editor) 621.311.17

Electric Generation—Steam Stations*

New York, McGraw-Hill, 1956. pp. x, 454. 24 × 16 cm. £3 4s.

Explains the basic principles governing the design of steam generating stations. Discusses coal and oil fuels, ash-handling, furnaces, boilers, turbines, condensers and cooling plant, water treatment and station auxiliary equipment. This book will be reviewed in a future issue.

UHL, A., and others 621.315.3

Interior Electric Wiring and Estimating. Part One. Residential, including farm buildings

5th ed. Chicago, American Technical Society; London, Technical Press, 1952. pp. vii, 326. 22 × 14 cm. £2 2s.

This work has now been expanded into two volumes (factory and industrial wiring being covered by Part Two). The various systems in use in the United States are described. Installation work is carefully explained and illustrated with many photographs and diagrams. There is a chapter on estimating, in which labour as well as material is considered.

For Part Two of this work see GRAHAM, K. C.

UNITED STATES ATOMIC ENERGY COMMISSION 621.039

Reactor Handbook. Engineering

New York and London, McGraw-Hill, 1955. pp. 1075. 27 × 20 cm. £5 12s. 6d.

Deals with the technology of reactors giving design data and formulae

and discussing the engineering problems involved. Covers fixed-fuel reactors using water, liquid-metal, or gas cooling and aqueous, liquid-metal, and fused-salt fluid-fuel reactors. Remote handling and control methods are described.

UNITED STATES ATOMIC ENERGY COMMISSION 621.039

Reactor Handbook. Materials

New York and London, McGraw-Hill, 1955. pp. 610. 27 × 20cm. £3 19s.

Gives physical, mechanical and chemical properties of over twenty materials and discusses their availibility and preparation.

UNITED STATES ATOMIC ENERGY COMMISSION 621.039

Reactor Handbook. Physics

New York and London, McGraw-Hill, 1955. pp. 790. 27 × 20cm. £4 10s.

Covers reactor physics and radiation shielding. Discusses theoretical and experimental techniques used in designing and evaluating research reactors.

WINCH, R. P. 537

Electricity and Magnetism*

New York, Prentice-Hall, 1955. pp. xii, 755. 24 × 16cm. £4 3s.

Assumes the student to have a background of college physics, including electricity and magnetism, and some acquaintance with differential and integral calculus. The rationalized M.K.S. system is used throughout the text which contains many worked examples and problems for the student to solve.

WOLFE, H. C. (Editor) 536.4

Temperature. Its Measurement and Control in Science and Industry

Vol. 2. Papers presented at the Third Symposium on Temperature, Washington, 1954

New York, Reinhold, 1955. pp. x, 467. 24 × 16cm. £4 16s.

This symposium was held under the joint auspices of the American Institute of Physics and the National Bureau of Standards to review developments since the previous meeting in 1939. There are twenty-four papers covering a wide temperature range and a variety of subjects.

OTHER PUBLICATIONS

INTERNATIONAL SCIENTIFIC RADIO UNION

Proceedings of the XIth General Assembly held in The Hague from August 23rd to September 2nd, 1954. Vol. 10. Part 2 Commission II on Radio and Troposphere.

Brussels, U.R.S.I., 1954. pp. 90. 24 × 16cm.

NATIONAL ELECTRONICS CONFERENCE

Proceedings. Vol. XI. October 1955

Chicago, National Electronics Conference, Inc., 1956. pp. xliv, 1040. 23 × 16cm. £2 2s. approx.

MONOGRAPHS AND PAPERS
published individually this month

MONOGRAPHS

A New Form of Electrolytic Tank

MONOGRAPH No. 195 M

K. F. SANDER, Ph.D., and J. G. YATES, M.A.

The chief cause of erratic results when field gradients are measured in an electrolytic tank by means of closely spaced probes has been shown to be variability of the meniscus near the probes. A new form of tank is described in which measurements are made by capillary probes in a plane defined by an insulating surface, thereby eliminating the meniscus effects present when the probes are placed in the free surface.

The Diffraction of an Electromagnetic Wave by a Circular Aperture

MONOGRAPH No. 196 R

R. F. MILLAR, M.A.

The effects of interaction across a circular aperture in a plane perfectly conducting screen are studied by application of the approximate edge-current diffraction theory previously developed, the interaction terms being found by asymptotic evaluation of the first-order aperture field. Their effect is examined by computing the aperture and axial fields and comparing the results with theory. An interaction correction to the geometrical-optics transmission coefficient is obtained. With an assumed current distribution over the entire screen, an expression is found for the transmission coefficient.

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Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

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Theory and Equivalent Circuits of the Double Induction Regulator

MONOGRAPH No. 197 U

C. S. JHA, B.Sc.

Tensor analysis is used to develop a comprehensive theory of the double induction regulator. The general case of a biased double regulator with completely dissimilar component single regulators is first examined. Working equations and equivalent circuits for other types of double regulator are then derived from those of the general case. Tests made on a simple (unbiased) double regulator are shown to agree closely with the behaviour predicted by theory.

Representation of Saliency on A.C. Network Analysers

MONOGRAPH No. 198 S

C. ADAMSON, M.Sc.(Eng.), and A. M. S. EL-SERAFI, B.Sc., Ph.D.

Existing methods of representing saliency on network analysers are discussed. These include combined reactance methods, and two methods using a d.c. signal to represent the e.m.f. of the synchronous machine. A simple method of representing saliency is then described together with the associated electronic circuits; the method uses an a.c. signal to represent the e.m.f. of the synchronous machine directly, and is associated with a network-analyser generator unit.

The Approximate Solution of Electric-Field Problems with the Aid of Curvilinear Nets

MONOGRAPH No. 199 M

L. TASNY-TSCHIASSNY, Dr.Tech.

A graphically-ascertained rough field plot can be used as the basis of a computing method of considerable accuracy. The plot is replaced by a net of orthogonal trajectories without sudden break of direction, in which the individual meshes are bounded by arcs of circles or straight lines. By using the nodes of this net as the junction points of conductances, the two-dimensional continuum within the problem boundaries can be converted into a network of lumped conductances. This network is analysed by measurement or computation. The paper deals with the graphical and computational layout of a net the contours of which follow closely the assumed trajectories, and explains the graphical and computational determination of the lumped conductance values. A large number of formulae and computing routines are derived, making the employment of semi-skilled workers or computing aids possible. The determination of the gradient and other special problems such as computing the areas associated with Poisson's equation or dealing with sharp corners are discussed.

Governing in Power Systems by Time-Error

MONOGRAPH No. 200 S

D. BROADBENT, Ph.D., B.Sc., M.Eng.Sc.

Governing in electric power systems by time-error provides a method of control with many advantages over speed governing, particularly if a high value of governor gain is used. The paper describes the operating results of a time-governed miniature system, the design of the governor for stable operation and the associated tie-line controllers.

PAPERS

The Measurement of Earth-Loop Resistance

PAPER No. 2165 M; PART A

G. F. TAGG, B.Sc., Ph.D.

Regulation No. 507 in The Institution's Regulations for the Electrical Equipment of Buildings calls for a measurement of the earth-loop impedance and gives a method by which this can be done. Several instruments have been devised and are available to carry out this test, but all draw their testing current from the mains and are thus liable to serious errors. Records taken with a recording voltmeter show that usually there is a voltage drop in the neutral conductor, which is varying continuously and rapidly. It is shown both theoretically and by practical tests that some instruments can have errors under these conditions amounting to 100% or more. Any instrument for measuring earth-loop impedance must be such that it will give the correct value despite the presence of the continuously varying voltage drop in the neutral. An instrument is described which draws its testing current from its own hand-driven generator and is free from these errors.

Differences of Opinion about Dimensions

PAPER No. 2167; PART B

PROFESSOR R. O. KAPP, B.Sc.(Eng.)

Contemporary differences of opinion among leading authorities about dimensions are numerous and often extreme. It is sometimes overlooked that the use made of the theory of dimensions is purely algebraic, and mistakes in elementary algebra are the cause of several of the more extreme opinions. It is shown that dimensional quantity appears as a synonym for independent variable, although considerations of convenience demand the arbitrary exclusion from dimensional equations of many independent variables.

The author demonstrates that the difference between rationalized and unrationalized units depends on the value of the unit given to a quantity that appears sometimes as an independent variable. This quantity has not always been recognized as such and has not received a name, but it might be called a 'configuration measure'.

A Dual-Comparator Mho-Type Distance Relay utilizing Transistors

PAPER No. 2177 S; PART A

C. ADAMSON, M.Sc.(Eng.), and L. M. WEDEPOHL, B.Sc.(Eng.)

The paper describes further work on a mho-type relay using transistors which depends for its operation on direct phase-comparison. The relay is rendered free from transient overreach by the use of a dual comparator circuit configuration. Relay accuracy is discussed and the methods which have been employed to improve the accuracy of the relay during operation without increasing its sensitivity are described. The tests applied to the relay and the reasons for their adoption are given briefly. Accuracy/range charts and dynamic mho-curves are presented for the relay connected as a phase-fault element with normal polarization, with polarization from an unfaulted phase and with the use of memory. The relay is a marked improvement over prototypes described earlier by the authors.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS AND CODES OF PRACTICE

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

Trolley and Contact Wire for Electric Traction (B.S. 23: 1956). 4s.

In this revision of B.S. 23 an additional standard size of contact wire (0·166 inch^2 section) has been introduced, primarily for use in high-voltage a.c. railway electrification. The requirements are substantially the same, for both copper and cadmium-copper wires, as in the previous edition, but a bending test is now specified in addition to the tensile, elongation and torsion tests. The electrical resistance is now related to the standard reference temperature of 20° C adopted generally in British Standards for electrical conductors.

Electricity Meters. Part 6. Direct Current Two-Wire Mercury Motor Credit-Type Meters (B.S. 37: Part 6: 1956). 2s. 6D.

Part 6 of B.S. 37 applies to d.c. two-wire credit-type meter equipments of the mercury motor ampere-hour and watt-hour types, which register in kilowatt-hours.

Standard current ratings and terminal-hole dimensions are specified. Information is given in the appendix regarding the precautions necessary to ensure accurate meter performance on test and in service.

This part of the Standard should be read in conjunction with Part 1, 'General Clauses Applicable to all Types of Motor Meter'.

Tungsten Filament General Service Electric Lamps (B.S. 161: 1956). 4s.

This British Standard is in its tenth revised form since it first appeared in 1921. The new edition replaces the 1940 version and all subsequent amendments.

In its new form B.S. 161 has been brought as closely as possible into line with the specification issued in 1954 by the International Electrotechnical Commission (I.E.C. Publication No. 64: 1954). The most important change produced by this 'alignment' affects the provisions for testing and quality control in the factory. In place of performance-limits based on average values and coefficient of variation, the new edition provides limits for individual sample lamps. Subject to a small working tolerance, all the sample lamps tested must show the prescribed level of performance before the complete batch may be passed as conforming to the requirements of the Standard. The purpose of this change is to control the quality levels of manufacture by taking into account the proportion of lamps which fall outside the specified limits. Although such lamps are not necessarily faulty, their proportion serves to indicate the acceptable level of quality.

The Standard deals very fully with the testing of lamps: it includes details of the method of selection of samples for testing and describes the statistical method on which the test quantities are based, and it describes the test conditions for mechanical and physical characteristics and for rating and life.

Method of Testing Vulcanized Rubber. Part C3. Permittivity and Power Factor of Insulating Soft Vulcanized Rubber and Ebonite (B.S. 903: Part C3: 1956). 2s. 6D.

This is the first revised part of B.S. 903 which relates to electrical tests. The document does not differ greatly from the 1950 version except in the layout and in the adoption of metric dimensions.

Supplement to Fireguards for Heating Appliances (B.S. 1945: 1953). 1s.

Since October, 1953, Statutory Regulations issued under the Heating Appliances (Fireguards) Act of 1952 have made it compulsory for all electric, gas, and oil-burning heaters to be fitted with safety guards which satisfy the requirements of B.S. 1945.

Difficulties in interpreting some sections of the Standard, and hence in observing the Regulations, have been experienced both by manufacturers of heating appliances and by local-government inspectors, whose responsibility it is to see that the Fireguards Act is properly complied with.

To help in avoiding such difficulties in the future the committee which prepared B.S. 1945 has, with the help and approval of the Home Office, now produced a supplement to the Standard. The supplement consists of a series of notes and three appendices which have to be read in conjunction with the original Standard.

Fixed Paper-Dielectric Capacitors for D.C. for Use in Telecommunication and Allied Electronic Equipment (B.S. 2131: 1956). 3s. 6D.

This is the first of a series of Standards dealing with components for telecommunication and allied electronic equipment. It applies to fixed capacitors using impregnated-paper dielectric and metal-foil electrodes, suitable for d.c. operation with or without a small superimposed a.c. component, and its requirements are applicable to capacitors of equivalent performance having other dielectrics. The capacitors dealt with are suitable for use over almost any desired range of temperature and humidity.

The use of the Standard requires reference to B.S. 2011, 'Basic Climatic and Durability Tests for Components', which fully describes the range of tests to which components may be subjected.

Tests carried out on components are designed to establish their suitability for use over stated ranges of temperature and humidity, their ability to withstand mechanical shock, and their ability to withstand normal assembly processes (e.g. soldering).

Electrically Heated Blankets for Domestic Use (B.S. 2612: 1956). 4s.

A Standard for electrically-heated blankets used in the home was first issued a little over a year ago, its objects being to ensure their satisfactory construction and safety in operation. Now, taking into account the experience gained during the past months, manufacturers and users have agreed on a revised edition of the Standard.

The most important features of the revision are concerned

with strengthening the Standard's safety precautions. For example, a new inflammability test has been incorporated to ensure that the materials used in blankets will not ignite. Highly inflammable materials such as kapok must not be used. Also, changes have been made to guard against the possibility of flame-proofing agents damaging the electrical components. A further modification is designed to minimize the possibility of electric blankets causing radio interference.

Reference Blocks for Routine Checking of Ultrasonic Testing Equipment Employing Shear Wave Probes (B.S. 2704: 1956). 2s.

In ultrasonic testing by the pulse-reflection or pulse-transmission methods it is desirable to be certain that the complete ultrasonic equipment is operating under conditions of reproducible sensitivity, so that the amplitudes of defect echoes may be directly compared. While tests are in progress this is particularly important (*a*) after valve replacements, (*b*) when adjustments have been made to the apparatus, and (*c*) if the instrument has to be interchanged with a similar instrument.

The simple reference block of the type specified in this British Standard is no substitute for full laboratory calibration of the electrical as well as acoustical variables involved; it is, however, considered that the block can serve a useful purpose by permitting rapid checks to be made on the instruments.

Non-Ferrous Conduit and Conduit Fittings (Aluminium and Zinc Alloy) (B.S. 2706: 1956). 6s.

The increasing use of aluminium conduit and aluminium-alloy and zinc-alloy conduit fittings in both domestic and industrial installations has led to the preparation of this Standard.

It covers the use of aluminium seamless tubing and aluminium-alloy and zinc-alloy fittings, used in conduit for electrical wiring, in the same way that B.S. 31: 1940 covers steel conduit and fittings. It is in fact based on B.S. 31 as far as is necessary to ensure interchangeability, and the types of fittings and important dimensions of components are identical.

The completion of the Standard followed the publication of E.R.A. Report V/T119 'Performance of Joints in Steel and Non-Ferrous Conduit and Fittings (excluding Copper)' by L. Gosland. It contains as Appendix C a copy of recommendations for the installation of aluminium-base-alloy and zinc-base-alloy conduit and fittings extracted from CP 321, 'Electrical Installations'. The Standard is cited, and provision made for the use of the conduit and fittings described, in the 13th Edition of The Institution's Wiring Regulations.

Another appendix gives recommendations for gauging.

Memorandum on the Measurement of Cooling-Medium Temperature when Testing Electrical Machines, Transformers and Other Electrical Apparatus (B.S. 2725: 1956). 3s. 6d.

In many Standards the test clauses refer to the temperature rise of the apparatus under consideration relative to a reference temperature. This reference temperature may differ in different industries and, in the past, cases have arisen where the requirements of test clauses have been interpreted in different ways.

With a view to avoiding differences in interpretation where the word 'ambient' is involved, this memorandum has been published by the B.S.I. It establishes a clear distinction between 'ambient temperature' and 'cooling-medium temperature'. The memorandum also gives guidance on the measurement of temperatures of cooling-media, and on suitable measuring instruments for laboratory and industrial use.

Preferred Standard Ratings and General Characteristics for 3 000 rev/min, 3-phase, 50 c/s Turbo-Generator Sets (B.S. 2730: 1956). 3s.

Standards for steam turbines and for turbine-type electrical generators have been established for many years, but until now there has not been a Standard to co-ordinate sizes of turbines and turbine-type generators and to indicate the preferred power ratings.

This Standard specifies preferred ratings for condensing-steam turbo-generator sets over a range from 10 to 120 MW. For the first part of the range (10–30 MW) air-cooled generators are specified, whilst from 60 to 120 MW hydrogen-cooled generators are covered.

The principal characteristics are given for both the turbines and the generators and an appendix deals with the determination of nominal exciter response.

PVC Insulation and Sheath of Electric Cables (B.S. 2746: 1956). 7s. 6d.

This Standard has been prepared to bring together in a single publication the methods of test and test requirements for various types of polyvinyl-chloride insulation and sheath taken from electric cables. A colour chart giving thirteen standard colours is included.

It will now be possible in future Standards for electric cables to give requirements for p.v.c. insulation and sheath by reference to this new Standard, and so avoid quoting test methods in full. It is understood that Defence Specification DEF–9, used by Government departments, will shortly be withdrawn in consequence of the publication of this Standard.

Memorandum on the Design of Electrical Apparatus having Double Insulation (B.S. 2754: 1956). 4s.

The normal method of protection against electric shock for all electrical appliances used in the United Kingdom is the connection of the frame or exposed metal parts of the appliance to earth. In recent years there has been a tendency for an alternative method known as 'double insulation' to be used. This method is particularly useful where a satisfactory connection to earth cannot be arranged, and it appears probable that the use of double-insulated appliances will increase.

The purpose of the memorandum is to explain the principles involved, and it is intended primarily for the use and guidance of B.S.I. committees. It is, however, likely to be of interest to all designers, manufacturers and users of electrical appliances.

The use of double insulation as a protection against electric shock instead of the method of earthing which is normally required, has been recognized in The Institution's Wiring Regulations, provided that the double-insulated appliance is the subject of an appropriate British Standard which has been approved for the purpose of the Regulations.

Copper and Cadmium-Copper Stranded Conductors for Overhead Electric Traction Systems (B.S. 2755: 1956). 5s.

This publication provides a range of standard stranded conductors suitable for overhead electric-traction systems. Contact wire has been standardized for many years in B.S. 23, but with the extensive electrification of railways a need has arisen for standard stranded conductors for such purposes as catenaries and feeders.

Apart from the wider range of sizes and different lay ratios, the requirements of the new Standard are similar to those of B.S. 125 and B.S. 672, which deal with copper and cadmium-copper conductors for power-transmission systems.

Glossary of Terms used in Industrial High-Frequency Induction and Dielectric Heating (B.S. 2759: 1956). 3s. 6D.

This glossary defines about 90 terms relating to the design and use of industrial high-frequency heating equipment, and is based on a 1952 publication of the British Electrical and Allied Manufacturers Association. It is divided into sections dealing with (*a*) general terms such as loss factor and tuning, (*b*) types of generator, including rotating machines, valve and spark-gap generators, (*c*) equipment such as filters and coaxial cable, and (*d*) applications and methods of heating.

In order to conform to usage in industry, some terms have been given meanings differing from those in general use. For example, the term 'high-frequency' is here applied to any frequency higher than that of mains supply.

The Use of Electronic Valves. Part 3. Photocells, Transmitting Valves and Cold-Cathode Gas-Filled Valves (CP 1005: Part 3: 1956). 3s.

This booklet, now published on the authority of the Council for Codes of Practice, covers requirements for photocells, transmitting valves and cold-cathode gas-filled valves. The new part should be read in conjunction with the recommendations for all electronic valves contained in Part 1, which was published in 1954 together with Part 2.

Part 3 expands the information given in Part 1 and also deals with specific aspects of the subject such as modulation-frequency response and relative spectral-response for photocells; ventilation and cooling of transmitting valves; and ionization and de-ionization in cold-cathode gas-filled valves. Reference is made in the document to the possibility of danger arising from X-radiation from valves operating at high voltages.

E.R.A. REPORTS

The Secretary has been asked to draw attention to the undermentioned E.R.A. Reports. Copies can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each report is given, and, unless otherwise stated, the cost of postage on a report is 4d.

G/T305. **Flameproof Electrical Apparatus: Flanged Joints, One Inch in Radial Breadth, in Mixtures of Acetone Vapour and Air** by T. J. A. Brown and N. Simpson. 7s. 6D.

For explosive mixtures of acetone vapour and air, ignited in a bronze sphere of 8 litres capacity with horizontal equatorial flanges 1 inch in radial breadth, the range of most inflammable internal mixtures was 5·0–6·5% of acetone vapour by volume; in the determination of the maximum safe gap a mixture containing 5·9% was used. The most readily ignitable external mixtures contain from 4·0 to 6·0% of acetone vapour by volume, and a mixture containing 4·5% was used in the determination of the safe gap.

L/T344. **Water Sorption in Heat-Treated Polystyrene and Plasticised Polyvinyl Chloride** by A. G. Day. 10s. 6D. (POSTAGE 6D.).

Heat treatment of polystyrene is shown to increase the sorption by about 20%. Tests on polyvinyl chloride (p.v.c.) at low humidities show a good correlation with the Brunauer–Emmett–Teller adsorption theory and provide theoretical confirmation of one of the constants. Activation energies for p.v.c. are calculated and the temperature dependence of the isotherms is shown.

L/T345. **A Phenomenological Treatment of Ferroelectricity and Antiferroelectricity in $NaNbO_3$** by L. E. Cross. 7s. 6D.

The Kittel–Devonshire phenomenological treatment of antiferroelectricity is extended to consider the modes of polarization of a pseudocubic crystal. Ten possible solutions of the free-energy function are given, corresponding to non-polar, ferroelectric, antiferroelectric and ferrielectric states. Using the experimental data for $NaNbO_3$, the author briefly describes the method of evaluating the coefficients in the energy function, and their values stated. The treatment gives satisfactory agreement with the observed values of phase change, optical anisotropy and dielectric constant for $NaNbO_3$, and a simple explanation of the observed phase changes in mixed $(NaK)NbO_3$ crystals.

V/T123. **Application of the Dispersion Test to the Drying of High Voltage Transformers** by D. C. G. Smith. 12s. 6D.

Recent work, reported in V/T118 and 122, has resulted in the development of an instrument (the dispersion meter) which detects the presence of moisture in electrical insulation such as oil-immersed paper, pressboard, synthetic resin-bonded paper, etc. In developing the use of this instrument in various fields, a study has been made of its application to the control of drying processes during the manufacture of high-voltage transformers. The present report describes the result of this study, and gives an indication of the possible use which can be made of the definite information obtained by the use of the instrument.

Z/T101. **Combination Spectra in Long-Period Variable Stars** by C. E. R. Bruce. 7s. 6D. (POSTAGE 3D.).

It is the purpose of the present report to suggest that the electrical discharge theory will account satisfactorily for the puzzling combination spectra observed in some of these stars. The states of excitation indicated by these spectra are so diverse that they have been, and often still are, believed to have their origin in a binary star and an associated nebula. However, a consideration of the nature of the long electrical discharges, already postulated to account for the general characteristics of long-period variable stars, suggests that they may account for both the nebular spectrum, and for the spectrum which has hitherto been attributed to a companion star.

Z/T102. **Stray Load Losses in A.C. Rotating Machinery. A Review of the State of the Art** by K. C. Mukherji. 24s. (POSTAGE 6D.).

Stray load losses in a.c. rotating machines are defined as 'the additional losses, wherever occurring, caused by the load current due to changes in flux distribution and to eddy currents'. Some theoretical, and a large volume of experimental, work has been done in the past with regard to such losses in synchronous and induction machines, and yet the present knowledge of the phenomena is by no means adequate for design purposes. A brief account is given in this report of the more important investigations, with critical comments on the assumptions involved, the methods employed and the results achieved.

B.E.A.M.A.

The Insulation Level of Power Transformers. 5s.

The increasingly high transmission voltages used for overhead lines necessitate special care in selecting the insulation levels for the lines and the associated equipment. B.S. 171, 'Electrical Performance of Transformers for Power and Lighting', is now under revision and is likely to include a new specification covering insulation levels and impulse voltage tests for transformers. The revision of this Standard, however, requires considerable time for consultation and discussion, and the B.E.A.M.A. has recently published a booklet with the above title to provide guidance in the interim period on British manufacturers' views about the selection of insulation levels and impulse voltage tests for power transformers. It has been prepared by the B.E.A.M.A. Transformer Technical Committee, and is based on recent studies of this committee. The booklet is available from the B.E.A.M.A., 36 Kingsway, London, W.C.2.

THE INSTITUTE OF WELDING

Health and Safety in Welding. 3s. (2s. TO MEMBERS OF THE INSTITUTE OF WELDING.)

The Institute of Welding has recently published a booklet which considers the health and safety of operators of welding equipment. The contents are practical and do not cover the advanced technical and scientific background of welding. It is offered as a concise work of reference both to the welding operator and to those responsible for the supervision of welding. There are four main parts: gas welding and cutting; arc welding and cutting; ventilation; and special precautions. The booklet is obtainable from The Institute of Welding, 2 Buckingham Palace Gardens, Buckingham Palace Road, London, S.W.1.

THE SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS

Recommended Mechanical Standards for Electrical Accessories. £1.

The Society of British Aircraft Constructors has recently issued recommendations for the design of certain mechanical features of rotating electrical machinery. These cover (i) ball and roller bearings; (ii) oil seals; (iii) general-purpose springs; (iv) electrical connections; and (v) tolerances. They are based on tried practices of aircraft engine and equipment design, with the intention of suggesting designs to meet the high standard of reliability required in aircraft.

Copies of the recommendations may be obtained from The Society of British Aircraft Constructors, Ltd., 29 King Street, St. James's, London, S.W.1.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st August 1956.

ELECTIONS

Associate Members

ANGERER, Ludwik.
BELL, John Frederick William, B.SC., PH.D.
BOWLES, Ernest George.
BROWNE, James Nicholas, B.SC. (ENG.).
BRYAN, George Alan.
BURTON, John Denzil.
COSTELLO, James Cormac, B.SC., M.E.
DEAN, John Robert, B.SC.(ENG.).
FORD, John Peter, M.A.
FORDE, Michael Joseph, B.E.
GRANT, Neil.
HARDEN, John Henry, B.SC.
ISTED, Charles Robert.
LONG, John Kenneth, B.ENG.
MEAD, Horace.
MURPHY, Donal Anthony Kevin, B.E.
NATTRASS, David.
PRICE, Sqdn.-Ldr. William Laurence, R.A.F., M.SC.
REID, Joseph Leonard.
ROBERTSON, Charles Stewart Lennox.
STENNING, Luis Charles, B.SC.
SUTHERLAND, John.
SWETMAN, Raymond Henry.
WHITE, Graham Charles Edward.

Associates

ADDERLEY, Edward John.
BERRYMAN, Leonard.
BOWEN, Dennis John.
HARDY, Stanley.
JACKSON, Raymond Arthur.
KHAN, Mohammad Aslam.
STELP, Richard Alexander.
STEPHENS, Peter Ronald Campbell, M.M.
TAN, Theam Ong.

TRANSFERS

Associate Member to Member

BAXTER, Philip.
BEDFORD, Christopher Ernest, B.SC. (ENG.).
BOLSHAW, Sam.
FARVIS, William Ewart John, B.SC., B.SC.(ENG.).
McLAREN, Colin Colby, B.A.
MERRILL, Frederick Henry, M.SC., B.ENG.
PARK, William Edwin.
RANDLE, Air Comm. George Hurst, B.A.
REID, William Ian Galbraith, B.E.
RICHMOND, Lt.-Col. Francis Arnold.

Associate Member to Member—continued

RIZWI, Abdul Qayyum, B.SC., B.SC. (ENG.).
SPENCE, William, B.SC.
VOHRA, Brigadier Satya Paul.
WEBSTER, Sydney.
WILSON, Graham Rudge, B.SC.

Graduate to Associate Member

BARNARD, Frank Frederick, B.SC. (ENG.).
BERRIS, Kenneth Victor William.
BLAKE, Derek Charles Loweth.
BRAIDFORD, John Leonard.
BRAND, George Edward.
CARR, Reginald Thomas Evomey, B.SC.
CAVE, Major Leslie, R.A.O.C.
CHAPMAN, John.
COURTNEY, Norman Ashwin.
DAVIES, Major Roy, R.E.M.E.
DICKINSON, Walter.
DOUGLAS, David Wright.
HACKE, Kenneth John Henry, B.SC. (ENG.).
HARRINGTON, Eustace Lionel Ernest.
HARRISON, Philip.
HEMINGTON, Graham Hugh.
HUDDART, Geoffrey William, B.SC.TECH.
JACKSON, George Albert.
KELHAM, Warwick Owen, B.SC. (ENG.).
LANE, Peter Edward, B.SC., PH.D.
LEANEY, Norman Farrell.
LIVINGSTONE, Harold.
LOVE, Thomas Blyth.
MAITRA, Jnanendra Chandra, M.SC.
MALONE, George.
MILNER, George Sydney, B.SC.(ENG.).
NAZIR, Badrudin Karmali, B.E.
NEWTON, Kenneth Ernest, B.SC. (ENG.).
OAKMAN, Peter Ernest.
REDDING, Robert John.
REED, John Alva.
REID, William.
SAMPSON, Derrick Peter.
SKETCH, Harold John Hannaford, B.SC.
SZABLOWSKI, Jerzy Zbigniew.
SZKLAREK, Stanislaw, DIPL.ING.
TAYLOR, Clifford Benjamin, B.SC.
TIN, Royston.
TRASK, Peter Darien, B.SC.
TRUSLOVE, David James, PH.D. B.SC.(ENG.).
TURNHAM, Arnold Eric.
WARD, George William, B.SC.
WEBSTER, Geoffrey Scruton.
WHITAKER, Horace Spedding.
YOUNG, David, B.SC.

Student to Associate Member

LUKEY, Edgar Pedersen, M.SC., B.E.

Student to Associate

ASHCROFT, Peter.

SOME RECENT BOOKS

G. G. GOURIET

AN INTRODUCTION TO COLOUR TELEVISION

NORMAN PRICE. 72 PP. 8s. 6D.

J. W. WENTWORTH

COLOR TELEVISION ENGINEERING

NEW YORK: MCGRAW-HILL. 478 PP. £3.

Mr. Gouriet's 72-page monograph is a reproduction of his two lectures to the Television Society. This little book is not a masterpiece of condensed wisdom, but in its two parts, entitled 'Colour Analysis and Synthesis' and 'Colour Systems', it provides an inexpensive and edifying glimpse into the basic concepts of colour television and into the structure of the N.T.S.C. transmission system. The balance of the text might have been improved if the author had not finished so abruptly on one page of 'Other Possibilities' and if, at the expense of colorimetry, more had been said about colour television apparatus. The book can be especially recommended to the technical reader who wishes to 'keep in touch' rather than to embark on a prolonged study.

Mr. Wentworth's book, compiled from lectures, aims at presenting the television engineer with an orderly introduction to the basic principles and instrumentation of colour television. The reader may feel that the title was not well chosen, for the author dwells hopefully on physics and psychology before coming to the less delectable engineering matters. Inevitably the book adopts as its central theme the processing and packaging of colour information; this is flanked on one side by the laboured physics approach and on the other by a prosaic description of colour television equipment. The style is sometimes eloquent but often wordy, and some of the illustrations might well have been omitted. Nevertheless, the book contains much that is interesting and useful to all classes of reader.

The first two parts deal mainly with the physics and psychology of colour; this is of interest to the uninitiated but it does not carry much weight in the remainder of the text. The concepts of colorimetry are adequately described, but the chapter on applied colorimetry makes only a vague reference to the necessary practical compromises. After describing the C.I.E. diagram the author later reverts to the handier Maxwell triangle, based on the colour television primaries, but does not provide any transformed colour perception data. Part 2 contains a welcome chapter on processes used in colour photography, concluding with a page on additive colour photography; here lenticular film is mentioned but not its possible application to colour television recording. The chapter dealing with electrical transfer characteristics is rather ponderous, but it includes a useful introduction to the problem of overall contrast compression.

Part 3 deals mainly with the particular signal-processing and multiplexing techniques employed in the single sub-carrier method of colour transmission. The reader will learn something of the underlying principles of the N.T.S.C. compatible colour system but he may be left wondering about the extent to which human vision and picture statistics are exploited.

Apparatus and circuits for the transmission and reception of colour television are described in Part 4. Here the author might well have presented a nicely balanced discussion of various camera and display devices, but instead has tended more towards a service-manual type of description. Nevertheless, the material at least carries the hallmark of practical experience and contains some useful hints and tips on circuits and test equipment. Colorimetric data and the F.C.C. colour signal specification are included in the appendices.

The book would have benefited from a more concise style; even so, it is a useful contribution and will prepare the reader for more specialized studies. It is of sturdy construction and can be recommended for use in the reference library.

RONOLD W. P. KING

TRANSMISSION-LINE THEORY

NEW YORK: MCGRAW-HILL. 521 PP. £4 10S.

Professor King's new book contains a large amount of useful material. On the whole it is systematically and clearly presented, and the mathematical derivations are lucid. The book can be safely recommended as a very useful addition to the library of an electrical engineer.

Nevertheless, there is some room for improvement. A detailed table of contents is a desirable feature, and also a list of symbols, preferably with clear verbal definitions, not only of the main quantities, but even of the auxiliary quantities, in addition to their algebraic definitions. Furthermore, the value of the fairly full list of references would be increased if more guidance were given to the sources of additional information.

Professor King's work is by no means a mere compilation. It is obvious that he has devoted a great deal of thought to various problems discussed in the book, to a number of which he himself has contributed by his own research. It would be of help to readers, especially those who use it for fundamental study, if the author's thoughts found more explicit expression, and if better connections were made between different parts of the book. There should be not only more cross-references, but also more explicit discussion of the relationship between various parts of the theory, especially where it is approached from different viewpoints. In many instances different methods of derivation and different forms of essentially the same relationships are given. This in itself is very valuable, but seldom are explanations offered of the relative advantages of these different forms, or of the intrinsic relationships between them. For example, the author does not explain the advantages of representing the curl (in Cartesian co-ordinates) in the form of a matrix; of using the scalar and vector potentials in the 'electromagnetic theory' approach (instead of using the Maxwell equations in their standard form); of the matrix form in the expressions for impedance and admittance in the 'lumped parameters' method; and of the 'scattering coefficient' in the 'travelling waves' method. Neither is it very clear from the book what are the advantages of the concepts of 'characteristic impedance'; of the Weissfloch transformer theorem; and of the Deschamps graphical method. On the other hand, there is a very interesting analysis of the relative merits of the 'electric circuit' and the 'electromagnetic theory' approaches to the transmission line, and there is a pertinent discussion of the differences between very close and comparatively remote parallel conductors.

Many electrical engineers would welcome more discussion

of the relation between the extensive theoretical information in the book and its application to engineering.

The book is well produced, and the text and formulae are well distributed, but it would be useful if some typographical emphasis were given to the more important results.

F. REINHARDT

PRUEFUNG UND ABNAHME VON ELEKTRISCHEN MASCHINEN, VOL. I

KARLSRUHE, GERMANY: VERLAG G. BRAUN. 125 PP. 28s. APPROX.

It is always a pleasure to read a book written by a practical man who can express the results of his experience in logical sequence. The author has been an engineer with a large firm for many years, and emphasizes throughout the book the great care needed in all measurements to obtain sufficient accuracy. For example, he points out that correct results depend largely on the accurate determination of speed, and devotes considerable space to this item.

This volume deals with the principles of measurement for all types of machine. The application to specific machines will be treated in the second volume.

The first section of the book is divided into the types of measuring apparatus used for machine testing: (i) measurement of mechanical quantities ranging from speed to moment of inertia; (ii) electrical quantities; (iii) thermal quantities giving the various methods of temperature measurement; (iv) aerodynamic quantities; (v) acoustic quantities and mechanical oscillations. All these subsections deal with the problems from the simplest cases upwards in a clear sequence.

The second section treats the testing of individual parts of a machine. It gives instructions for finding the resistance of d.c. and a.c. windings, the polarity and axis of a winding, insulation strength, static and dynamic balancing, and over-speed tests. The last section explains the various types of test for completed machines, including no-load, short-circuit and full-load testing, and tests for starting and regulating.

The book is particularly suitable for students, but senior engineers will find it of great use for reference.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month that a synopsis appeared in the *Journal* under 'Monographs and Papers published individually this month'.

October 1956

O **4** *Thursday* SIR GORDON RADLEY, K.C.B., C.B.E., PH.D. (ENG.). Inaugural Address as President‡

M **9** *Tuesday* DENIS TAYLOR, M.SC., PH.D. Chairman's Address 'The Measurement of Radioactivity'‡

U **11** *Thursday* H. J. GIBSON, B.SC. Chairman's Address 'Balanced Development and Diversity of Applications'‡

I **15** *Monday* The President will open a discussion on 'Telephone Development in the United Kingdom'*

R **17** *Wednesday* R. C. G. WILLIAMS, PH.D., B.SC.(ENG.). Chairman's Address 'The Electronic Age'‡

E **19** *Friday* V. ATTREE, B.SC.(ENG.) will open a discussion on 'Experiments for the Electronics Laboratory', before the Education Discussion Circle* (At 6 p.m., tea at 5.30 p.m.)

R **22** *Monday* Informal Evening on 'The Use of Transistors in Radio and Television', at which there will be talks given by A. J. BIGGS, PH.D., B.SC., and E. WOLFENDALE, B.SC.(ENG.)†

M **23** *Tuesday* R. W. SUTTON will open a discussion on 'The Use of Electronic Computers in Nuclear Reactor Design Studies'†

S **24** *Wednesday* P. J. RYLE, B.SC. Chairman's Address 'Engineering Efficiency, Economics and Expediency'‡

O **25** *Thursday* (In conjunction with The British Nuclear Energy Conference.) L. R. BLAKE, PH.D., B.SC. 'Conduction and Induction Pumps for Liquid Metals' (Paper No. 2111 U)‖ *Synopsis:* July 1956

RM **29 to 2nd November** *Monday–Friday* Convention on Ferrites. (Particulars issued with the June *Journal*.)

* No advance information will be available and no Press report will be permitted.
† An abstract of the introduction will be available in advance.
‡ No advance information will be available.
‖ This paper has now been published individually.

District Meetings

Arrangements for District Meetings in October other than those in the area of a Local Centre.

OXFORD (At the Southern Electricity Board, 37 George Street, Oxford, at 7 p.m.)

1956

October 10 *Wednesday* M. J. KELLY, PH.D., D.ENG., D.SC., LL.D., SIR GORDON RADLEY, K.B.E., C.B.E., PH.D.(ENG.), G. W. GILMAN, M.S., and R. J. HALSEY, B.SC.(ENG.). 'A Transatlantic Telephone Cable'

Proceedings I.E.E., Paper No. 1741, September 1954 (102, Part B, p. 117)

READING (At the Small Town Hall, Reading, at 7.30 p.m.)

October 1 *Monday* C. F. McCUE, B.SC. 'Insulating Oils for the Electrical Industry'*

* No advance information will be available.

British Nuclear Energy Conference: Forthcoming Programme

SEPTEMBER 25 *Tuesday*

A meeting sponsored by The Institution of Civil Engineers will be held in the Building of that Institution, Great George Street, London, S.W.1, at 5.30 p.m. (tea at 5 p.m.). The following paper will be presented and discussed:

THE PROBLEM OF LIQUID AND GASEOUS EFFLUENT DISPOSAL AT WINDSCALE F. R. Farmer

The paper reviews the many aspects of the radioactive effluent problem affecting the design and operation of the Windscale works of the Atomic Energy Authority. The choice of the piles and chemical processes is shown to be partially dependent on their respective effluents, and the site is chosen to permit reasonable flexibility in effluent discharge.

A provisional assessment of effluents is made during the design stage, and the extensive theoretical and experimental investigations carried out to determine acceptable levels of radioactive discharge are described in the paper.

The effect on the environment as a result of discharges made during initial plant operation is presented. It is concluded that the release of activity under carefully controlled conditions is possible whilst still conforming with the recommendations of the International Commission on Radiological Protection.

The experience gained as a result of four years' operation provides the first practical data on the release of radioactivity from industrial plant and constitutes an essential background for the continued development of nuclear energy.

OCTOBER 25 *Thursday*

See Forthcoming Events at Savoy Place, p. 559.

NOVEMBER 22 *Thursday and* **23** *Friday*

A Symposium of papers on the Calder Works Nuclear Power Plant, which will be held at The Institution of Civil Engineers, Great George Street, London, S.W.1. A slightly revised version of the programme for the Symposium that was published in the August *Journal* appears below. Advance copies of the papers will be available at the beginning of November to members who wish to attend the meetings. The papers and discussions will be published in *The Journal of the British Nuclear Energy Conference*. A registration fee of £1 will be charged towards the cost of the advance copies. All those wishing to attend are requested to obtain an application form from the Secretary, British Nuclear Energy Conference, 1–7 Great George Street, London, S.W.1.

Introduction to the Symposium

On the 18th May 1956, when loading of uranium started, the first half of the Calder Hall nuclear power station was complete and tested. Four days later, the first reactor had become critical. The plant is now moving into full commission; and the culmination of this year's activity will be the ceremonial opening of the station by Her Majesty the Queen on the 17th October.

The great significance of this plant is that not only is it the first large-scale nuclear power plant in the world, but it is the prototype from which nuclear power stations of several times greater output are currently being designed by industrial manufacturers.

Much has been written about nuclear power plants, mostly concerning what may (or may not) lie in the future. In contrast, this Symposium is a report of work done and results achieved. It has been planned to cover all aspects of science and engineering associated with the design and construction of the plant.

With the expanding development of nuclear power, many engineers and scientists will be drawn into this new field. To the newcomers the Symposium will give a realistic picture of what is involved in the design of a new plant using nuclear fuels, in particular the magnitude of research and design effort. To those already working in this field, the completeness of the subject matter will make the Symposium of great interest, and the published papers and discussions indispensable references.

SESSION I *10 a.m. Thursday 22nd November*

INTRODUCTION AND GENERAL DESIGN

Chairman: Sir John Cockcroft, *Chairman of the Board*

CONFERENCE PROCEDURE Sir John Cockcroft

1 THE PLACE OF THE CALDER HALL REACTOR IN NUCLEAR POWER GENERATION Sir Christopher Hinton

2 THE 1951–53 HARWELL DESIGN STUDY R. V. Moore and B. L. Goodlet

3 THE DESIGN AND CONSTRUCTION OF THE PLANT R. V. Moore

DISCUSSION

Reporter: R. V. Moore

SESSION II *2 p.m. Thursday 22nd November*

TECHNICAL RESEARCH PROBLEMS

Chairman: Sir John Cockcroft

4 EXPERIMENTAL HEAT TRANSFER WORK P. Fortescue and W. B. Hall

5 EXPERIMENTAL PHYSICS P. Mummery

6 SHIELD DESIGN C. C. Horton and W. Bonsall

7 BASIC DESIGN OF REACTOR G. Packman and B. Cutts

DISCUSSION

8 EARLY METALLURGICAL PROBLEMS R. A. U. Huddle and L. M. Wyatt

9 METALLURGICAL DEVELOPMENTS L. Grainger and A. B. McIntosh

DISCUSSION

Reporters: J. Diamond and L. Rotherham

SESSION III *10 a.m. Friday 23rd November*

ENGINEERING DESIGN

Chairman: Mr. W. L. Owen

10 DESIGN AND CONSTRUCTION OF REACTOR VESSEL G. Brown, M. Noone and R. F. Bishop

11 URANIUM FUEL HANDLING K. Dent and G. W. Grossmith

12 DESIGN OF IMPORTANT PLANT ITEMS A. T. Bowden and G. H. Martin

DISCUSSION

13 STEAM CYCLE ANALYSIS W. R. Wootton

14 DESIGN AND CONSTRUCTION OF HEAT EXCHANGERS H. Morris and W. R. Wootton

DISCUSSION

Reporters: Sir Claude Gibb and R. E. Zoller

SESSION IV *2 p.m. Friday 23rd November*

LIGHT ENGINEERING AND ELECTRICAL

Chairman: Mr. J. Eccles

15 EQUIPMENT FOR CONTROL OF THE REACTOR J. H. Bowen and S. A. Ghalib

16 DETECTION OF FAULTY FUEL ELEMENTS E. Long, J. M. Laithwaite and K. W. Cunningham

17 REACTOR CONTROL AND INSTRUMENTATION R. J. Cox and K. R. Sandiford

18 SYSTEM CONTROL AND PROTECTION J. H. Bowen and E. Anderson

DISCUSSION

Reporter: Denis Taylor

SESSION V *5.30 p.m. Friday 23rd November*

FUTURE DEVELOPMENTS AND SUMMARY

Chairman: Sir John Cockcroft

19 FUTURE DEVELOPMENTS OF GAS-COOLED REACTORS R. V. Moore

20 SUMMARY OF PROCEEDINGS P. T. Fletcher

LONDON

MEASUREMENT AND CONTROL SECTION

Steady Sailing

Ship Stabilization: Automatic Controls, Computed and in Practice was the title of the Annual Section Lecture delivered on the 8th May 1956, by Mr. J. Bell. For an hour and a half the audience was held in close attention whilst the lecturer gently traced the development of stabilizing control devices with the aid of over thirty slides and numerous demonstrations and models.

Many methods of applying restoring forces have been proposed, such as water tanks, water jets, moving weights, massive gyroscopes and moving fins, of which only the last method has survived and is now in use in over a hundred vessels. It was to the development of satisfactory control gear for this that the lecturer devoted most of his attention.

Just before the Second World War renewed attention was directed to the problem; in the first place open-loop models were made having the sequence of sinusoidal disturbance, rolling table, gyro, fin control and fin, and all computation was manual. Later small vessels were fitted with the device, and we had the closed-loop system of sea, ship, gyro, fin control and fin, with feedback loops from fin control to gyro and from fin to ship. The control was the on-off kind and its performance was observed under conditions of gentle swell, confused sea, and even under conditions of forced rolling obtained by reversed control, which was said to have some naval uses. It must be an odd sight to see a ship with a violent roll on a calm sea. On-off control, however, produced a lot of vibration and had very large power requirements.

Mr. Bell then went on to consider direct roll control and derivative roll control. He pointed out that with a beam sea the ship rolls with its own natural period, which for purposes of analysis is presumed to be sinusoidal, and the only difficulty in simply applying antiphase roll control is the time lag in the control mechanism.

The first derivative of roll (velocity) gives a sine curve displaced 90° from the roll curve, the second derivative (acceleration) being displaced a further 90° and a third derivative (rate of change of acceleration) a further 90°; thus there are cancellations between roll and second derivative and between first and third derivatives. This is true only if the ship's motion is harmonic; if it is not, derivative controls may be applied.

The practical apparatus employs a combination of roll and roll-velocity control effected respectively by a vertical-keeping gyro and a velocity-sensitive gyro. Their combined motions are transmitted to a hydraulic relay which applies continuous control to the fin-operating mechanism.

At a later stage an analogue computer was employed in which direct and first and second derivative control were introduced. This was found to be very helpful, but the lecturer thought fit to remind us at this point, and again later, of the saying that 'the only law of the sea is that there is no law'.

There was a most impressive and convincing demonstration in the Lecture Theatre by means of a pivoted platform about four feet square carrying fins and control gear, a mast, and a picture of the fore part of the ship looking into her bows. Simulated sea action was produced by a rotating jet of air at the mast-head and jets of air on the fins. Various kinds of control were applied including reversed control, and it was suggested by Dr. Denis Taylor in moving a vote of thanks that Mr. Bell had switched off only just in time, since the audience in front of this model was beginning to show signs of serious discomfort. M. W.

RADIO AND TELECOMMUNICATION SECTION

Highways in Exchanges

The advent of electronics and time-division multiplex in telephone exchanges would seem to introduce a common element in the old established arts of automatic telephony and that of the carrier and radio engineer. With this in mind, the Chairman, Mr. H. Stanesby, remarked of the paper presented on the 9th May 1956, by Mr. L. R. F. Harris, that his subject, *Time Sharing as a Basis for Electronic Telephone Switching*, was the first of its kind to be given since the Section had assumed responsibility for line communication.

The paper showed that, in all telephone systems to date, economies in switching apparatus have been effected by the application of time-sharing techniques based on traffic studies. The introduction of electronic techniques has enabled speeds of operation to be increased with a large improvement in availability of apparatus for time sharing. In the new system, pulse channels over common leads establish the connections, and access to any line may be obtained from each of the pulse channels; these in turn are controlled by register and supervisory apparatus in which information is stored and subsequently retransmitted by common apparatus that operates on the connection pulse channels. Switching can be effected between pulse channels on different highways for the transmission of speech frequency signals. Mr. Harris covered the field in some detail with the aid of a coloured film strip which was arranged to step each frame into position as required, and alternative routes were clearly shown by adding coloured lines to the diagram. A short review of the paper appears on p. 520.

The discussion ranged somewhat broadly over the subject in hand, as well it might in such a vast expanse of untried seas, and it was evident from remarks made by Mr. G. C. Hartley, who opened the discussion, and subsequently by Mr. G. T. Baker, that the course of future trends in electronic exchange design had not yet been charted, and experience alone would show which of the routes proved the best. Time sharing on an electronic basis could be applied to the speech path, to the control equipment or to both as desired. Mr. Hartley further envisaged time-division coding techniques which would be capable of providing both-way two-wire communication.

Mr. D. A. Barron felt that electronic switching was ideal for trunk switching networks where advantage could be taken of its speed, particularly if the dial were to be superseded by a faster sending device. On the other hand, Mr. T. H. Flowers considered that the switched-highway system showed up to maximum advantage in large exchanges—and for small exchanges he envisaged simpler time sharing by employing a two-wire both-way gate.

Amongst the opinions expressed by the many who took part in the discussion, Mr. N. C. Smart thought that the development from time sharing by switching to time sharing by sampling and coding was a logical step in the development of the automatic exchange; Colonel C. E. Calveley wished to see the principle of time sharing extended down the subscriber's line, thereby effecting a saving in copper; Mr. L. J. Murray pointed to the increasing cost if all groups of the switched-highway system were to be interconnected; and Mr. E. P. G. Wright stressed the importance of making the design give preference to ease of maintenance rather than ease of trunking and he put in an appeal for a detailed study of the maintenance methods to be applied in electronic exchanges.

It is significant that nobody objected to time sharing or to the principle of the switched highway system—in fact Mr. G. W. Thompson wanted the principle extended so that the speech path was switched through only when speech energy was being transmitted. This surely was measure enough of the success of the paper and the ideas behind it.

In his reply to the discussion, the author confined himself to the broader issues of the ideas put forward, for this was, in fact, the only way to deal with the many views expressed by the members of a well-attended meeting. T. B. D. T.

UTILIZATION SECTION

Underground Trains

At the meeting on the 15th May 1956, Mr. T. E. Green presented a paper entitled *Mine Locomotives*, which reviewed the conditions and restrictions governing the use of locomotives in British coal mines and the designs which had been evolved to meet them. The author stated that during the past 15 years over 800 battery-electric and Diesel locomotives, covering some 40 different designs, had been put to work; 25% of these were battery-driven and 75% Diesel-driven. As the amount of coal transported underground in Britain by locomotive-hauled trains was still less than 20% of the total mined, it was clear that an immense field remained for investigation. Even now, with the advent of locomotives of modern design, a great deal of running was done at speeds of less than 10 m.p.h., and, accordingly, a radical approach to the whole problem of haulage was necessary. In this connection, the solution might lie in trains operated by remote-control running on special roads at speeds of 30–40 m.p.h.

The ensuing discussion was opened by Mr. A. E. Crook, who said that experience of underground transport by locomotives had shown its outstanding advantages, both for production and safety, and he also gave some interesting figures showing their very successful and extensive use in the coal mines of other countries. Regret was expressed by one speaker at the very large proportion of locomotives operating in British mines which were Diesel-driven and at the fact that there was only one trolley locomotive installation in the whole country, which, apparently, was due to the special regulations applying to trolley locomotives and not to Diesels. This position, he felt, would be materially altered if higher voltages could be permitted with an increased height of trolley wire, as was allowed in German mines. Another contributor considered that a properly designed signalling system underground could do a great deal to increase safety and to speed up transport, particularly in the vicinity of the shaft at the pit bottom. R. H. R.

BIRMINGHAM

SOUTH MIDLAND CENTRE

Always one of the high-lights of the year is the Centre Dinner, and that at Birmingham on the 3rd February 1956, was of special interest, since Sir George Nelson was present in the dual capacity of President and member of the Centre. His speech contained much of significance about the activities of The Institution, and he urged members to take an ever increasing interest in the education of engineers. He also encouraged engineers to play a bigger part in the affairs of the country as a whole. Witty and informative speeches were made by the other principal guests, the Lord Mayor of Birmingham, the President of the Birmingham Chamber of Commerce, Mr. E. M. Clayson, and Mr. T. A. Hamilton-Baines. Mr. H. S. Davidson was in the chair.

The practice of the Centre holding combined meetings with Specialized Groups has continued, and such meetings have taken place with the Supply and Utilization Group, the Radio Group, the Graduate and Student Section, and the Education and Discussion Circle. On each occasion the Group Chairman has joined the Centre Chairman on the platform.

The Students' Night took the form of a meeting for the presentation of three short papers, and as previously, this was a great success.

A particularly interesting discussion arose on the 7th May at the presentation of the paper on *Problems of Hydro-Electric Development in Mixed Thermal–Hydro-Electric Systems* by T. G. N. Haldane, and P. L. Blackstone, when the authors were forced to digress into the realm of atomic energy; amongst other things Mr. Haldane prophesied that, at an atomic fuel station, the cost of electricity would be a negative quantity.

The Supply and Utilization Group held a Summer Meeting on the 13th June, when a visit was made to the works of Doulton Industrial Porcelains Ltd. After lunch members and guests went to Lichfield Cathedral, where they were received by the Dean, who gave an interesting historical account of the building and its surroundings.

The Graduate and Student Section followed up a Summer Meeting with the Students of The Institutions of Civil and of Mechanical Engineers with the Annual Joint Dance, which was most successful.

Fifteen Section meetings were held during the session, and nine of the papers presented were by Graduate and Student members. R. H. P.

CAMBRIDGE

MEASUREMENT AND CONTROL SECTION

Psychology, Engineering, and Lady Margaret

The Annual Summer Visit of the Measurement and Control Section took place on the 15th June 1956, when the members and ladies met in Cambridge.

One half of the party availed themselves of an invitation extended by Sir Frederick Bartlett, at the Section Dinner last November, to visit the Applied Psychology Research Unit, and they were duly received by the Director, Dr. N. H. Mackworth. The aims of the unit are to observe and measure human behaviour in order to establish general principles for healthy human performance. The investigations consist of those experimental studies of individual human activity, and those

who chose to visit this establishment were given an insight into the practical value of research projects, which for many were quite new subjects.

The remainder of the party visited the University of Cambridge Engineering Laboratory, where they were received by Professor J. F. Baker and Professor E. B. Moullin. The visitors were impressed with the arrangements provided for post-graduate instruction and research, and particularly with the work which is being done on the theory and application of automatic control.

Luncheon, at which Mr. W. Bamford, the Chairman of the Section, presided, was served in hall at St. John's College, where covers were provided for 90 members and their guests. After the loyal toast Mr. Bamford expressed the thanks of the Section to the College Council for allowing luncheon to be taken in the pleasant atmosphere of St. John's, and to Sir Frederick Bartlett and Professor Baker for permission to visit their Laboratories. Professor Baker replied that there were many more items of interest that might have been shown had time permitted, and that in going on to Ely the members would see the earliest 'space frame' in the world-famous Octagon. Sir Frederick Bartlett, on behalf of the Master and Fellows, said it gave them great pleasure to have the members of the Section at St. John's, and observed that the Secretary of The Institution was himself an Old Johnian. The psychologist had a good deal to learn from the engineer, and although they work in different directions, it was certain they would continue to work together.

In passing it may be mentioned that a tablet to Ambrose Fleming has recently been placed in the Chapel of St. John's College, where there are also tablets to Gilbert and Parsons.

In the afternoon the party proceeded to Ely, where they were received by the Dean, and conducted over the Cathedral.

Tea was provided in delightfully quaint rooms at Ely, where members and their guests were entertained by Mr. G. A. Whipple, who recalled his interesting period of service on the Council, and expressed his pleasure at meeting the members of the Section. He hoped the meal had been a 'positive feed', and congratulated the Committee in arranging for the outing to terminate in so picturesque a neighbourhood.

PAIGNTON

SOUTH-WESTERN SUB-CENTRE

Vice-Presidential Visit

May 10th was the day of a Vice-Presidential visit to the Sub-Centre. This special occasion called for a special meeting place. Oldway Mansion, Paignton, with its ornate and beautifully painted Italian *décor* and its marble stairways and floors, was very fitting and provided much pleasure. In the morning the Committee met there in the Council Chamber of the Paignton Urban District Council, by whose kind permission the ballroom of the Mansion was also used in the afternoon for the 86th ordinary meeting.

At this meeting the Chairman, Mr. W. J. Guscott, welcomed Dr. Willis Jackson, and introduced him to the members. The Chairman also welcomed visitors and guests, in particular Mr. E. Leete and Professor G. H. Rawcliffe (Senior Vice-Chairman of the Western Centre). In reply the Vice-President expressed his pleasure in visiting the Sub-Centre and at meeting his friends there. Dr. Willis Jackson spoke of some of the problems now facing the electrical industry, particularly anxiety about recruitment. He touched briefly upon the changes which had taken place in The Institution's *Journal* and concluded by stressing the value of greater support of the Benevolent Fund.

Mr. A. B. Thomas, a member of the Sub-Centre, then gave his paper on *Radio Astronomy*. His personal experience in research, together with some fine lantern slides, provided a completely absorbing and fascinating subject. A very good discussion followed, opened by Mr. C. H. Foulkes. Mr. Gordon Monk jocularly remarked that some of the deductions mentioned in the paper regarding galaxies at a distance of 10^9 light-years seemed perhaps a little 'far fetched'.

In the evening an informal dinner was held at the Palace Hotel, Paignton. The loyal toast was followed by the toast of 'The Institution', proposed by Mr. E. M. Bishop, Chairman of Paignton Urban District Council. Having thanked the Chairman for his invitation, he spoke of the 'great electrical adventure' which was taking place at the moment and the therefore obvious importance of the work of The Institution.

Responding, Dr. Willis Jackson said it was a privilege to reply for The Institution, a body now of 40 000 members, of which 20 000 were Corporate Members responsible for the work of perhaps 1 000 000 men. Speaking of the tremendous and sustained expansion of the industry, Dr. Willis Jackson referred to the nuclear plant programme and the possibilities of development in this field. He mentioned the wide scope of electrical engineering, now and to come—colour television, traction, automation—and how all this made the problem of recruitment into the profession more urgent.

The toast of 'The Sub-Centre' was proposed by Mr. A. N. Irens, Chairman of the South Western Electricity Board. Mr. Irens spoke of the good spirit and enthusiasm of members of the Sub-Centre and he noted that by reason of its non-industrial territory the Sub-Centre had a majority of electricity supply members. He said that the foundations of the South Western Sub-Centre had been well laid in 1937 as the Devon and Cornwall Sub-Centre. He also made reference to the occasion during the past war when Mr. Culmer Hodges gave his Chairman's Address on *Post-War Reconstruction*, only to find the city of Exeter, where the Address was delivered, visited by Hitler's Luftwaffe and severely blitzed the following day. Mr. Irens concluded by saying that he considered it most important that the engineers of the South Western Electricity Board should actively participate in Institution affairs.

In response Mr. W. J. Guscott thanked Mr. Irens for the kind way in which he had proposed the toast. Referring to the majority of supply industry members, Mr. Guscott said he was pleased that, although the other sides of the industry lacked quantity in representation, especially on the Committee, there was no lack of quality. The Sub-Centre, said the Chairman, tried not to be an unruly child of Western Centre parentage. But the Sub-Centre prided itself upon an independent spirit and was grateful for the tolerance and understanding shown at all times and particularly in the previous year when Mr. Irens was Chairman of the Western Centre. Founder members of the Centre present were Mr. Gordon Monk, Mr. W. E. Johnson and Mr. W. F. Smith. The Sub-Centre's members were proud that Mr. Leete, an Honorary Member of The Institution, now lives in their territory. Mr. Guscott said the Sub-Centre was very pleased that Professor Rawcliffe was present to represent the parent Centre.

The success of the evening was largely due to the considerable and untiring efforts of Mr. W. E. Johnson, and the Chairman concluded by asking the members present to record their appreciation of Mr. Johnson's work in organizing the event.

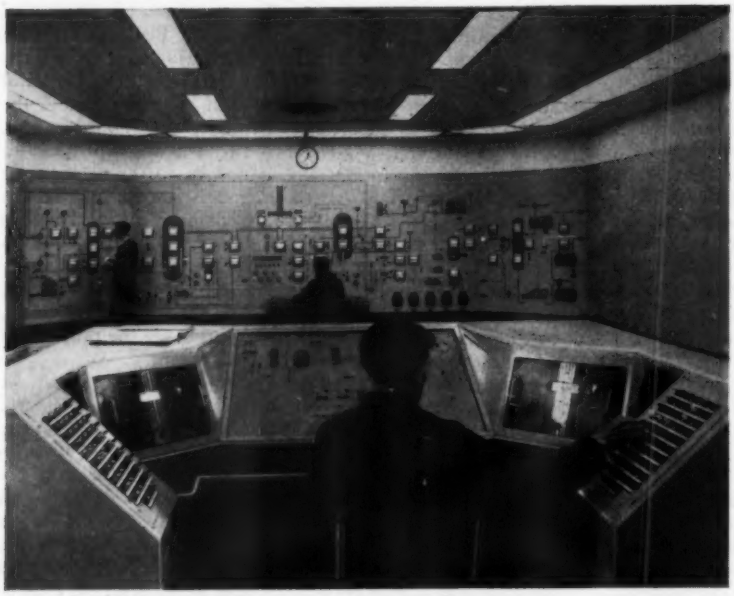
G. B. H.

SOUTHAMPTON

SOUTHERN CENTRE

Automatic Control on the Summer Visit

The Summer Meeting of the Centre took place this year on the 8th June and consisted in the main of a visit to the Fawley oil refinery of the Esso Petroleum Company. The invitation to make the visit was conveyed by Mr. E. Asquith, a member of the Southern Centre Committee, who is also Chief Engineer of the refinery. Arrangements for the visit were handled by Mr. Brammer.



A control room of the Esso Fawley refinery visited by members of the Southern Centre

Of particular interest are the multi-channel recording instruments which feed back information to control the conditions which they are recording.

Those taking part in the visit looked forward to meeting Mr. Asquith during the visit, but he was absent from Fawley and it was with pleasure that they learnt that this was due to duties arising from his acceptance of a higher appointment, that of Assistant Refinery Manager. The party were however charmingly received by his colleagues, Mr. Young and Mr. Follett of the Public Relations Department, Mr. Driscoll, Assistant Chief Engineer, and Mr. Collins the Electrical Engineer. It was a very sincere compliment to the Centre that these busy people devoted their afternoon to explaining the intricacies of the plant.

There are many available descriptions of the Fawley plant and it is not intended to refer to this in detail. The most impressive points which the visit revealed were first the very small number of people engaged in day-to-day operation owing to the completely automatic control, and secondly the nature of the control. The ratio of operation to maintenance staff is approximately 1 to 3. Whilst the automatic control used may be normal practice in refining work it presented some novel features to many of the visitors. For example, it appears to be quite usual in refinery practice to use the elements of a recording instrument to feed back information to the point of control for process control purposes. The degree of compression of information in the control room by the use of multi-trace charts and small instruments is highly commendable and will no doubt lead to similar developments in other continuous processes where automatic control is being extended.

During the afternoon the ladies in the party visited the delightful surroundings of Beaulieu Abbey. In all 96 members and their ladies were entertained to lunch and to tea by their hosts, and Mr. Fuller expressed their thanks to the Esso Petroleum Company for its hospitality.

Golf Competitions

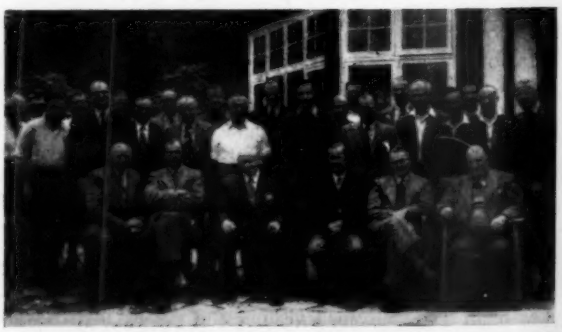
The Southern Centre Golf Competitions in aid of The Institution's Benevolent Fund took place on the 19th June 1956, at Stoneham Golf Club, Southampton. This tournament was open to all members and their friends. The results were as follows:

Competition No. 1. Pirelli-General Cup, 18-Hole Single Medal Competition

This was won by Cmdr. W. A. Kyle with a score of 76. Cmdr. Kyle also won this event in 1954. In addition, the prize to the competitor with a handicap of 15 or under returning the best score was won by Mr. N. H. Sennett with a net score of 73. The prize to the competitor with a handicap of 16 or over returning the best net score was won by Mr. C. J. Penny with a net score of 71.

Competition No. 2. R. H. Coates Cup. 18-Hole Four-Ball Competition under Handicap against Bogey

This was won by Cmdr. W. A. Kyle, R.N., and Mr. J. E. Brunner, who were also last year's winners, with the best net score 4 up on bogey. The second best net score 2 up on bogey was returned by Mr. N. H. Sennett and Mr. E. Gill.



Members of the Southern Centre and their friends outside the club-house at Stoneham, near Southampton, on the occasion of the Golf Competitions

Front row, left to right: Mr. G. D. Arden (Local Hon. Treasurer of the Benevolent Fund); Cmdr. C. V. Robinson (Past-Chairman); Mr. E. A. Logan (Past-Chairman); Mr. L. H. Fuller (Chairman); Mr. H. Robson (Chairman-Elect); and Mr. J. A. P. Farrant (Past-Chairman).

Competition No. 3. Putting

This was won by Mr. G. C. R. Plant with a score of 33.

The weather was very kind to the competitors, the day being slightly overcast with only a slight breeze and no rain to mar play. The arrangements were made by Mr. G. D. Arden and the sum of £60 was raised for the Benevolent Fund.

E. A. L.

YORKSHIRE

UTILIZATION SECTION

A Full Week-end

The thing we shall all remember about the Utilization Section Summer Visit to Harrogate in May 1956 is the sunshine—cold winds perhaps, but brilliant sunshine and blue skies which made the Yorkshire countryside, the Yorkshire air, and lovely Fountains Abbey, memorable for us all. The hillsides and the moors welcomed us in fresh spring green, the rivers sparkled and even the grim grey walls and fierce grey horned sheep seemed almost friendly. In fact, one heard from everyone a wish to return to Yorkshire for a more prolonged visit.

We should not be British if we did not comment on the weather first but it was not only the weather which contributed to the success of this Summer Visit. There was a very well planned programme for everyone to enjoy, and although the feet perhaps were weary by the time we set off for home (how the ladies hobbled on the cobbled way in the York Castle Museum) everyone agreed that it had been a thoroughly successful week-end. The Cairn Hydro Hotel was very comfortable and the service excellent—real Yorkshire hospitality for us as we arrived at tea time on Friday, and met old and new friends in the lounge.

Saturday was a very busy day. In the morning the Ladies went to I.C.I.'s truly wonderful new Terylene factory just outside Harrogate. It left us speechless with admiration and possibly green with envy where the furnishings were concerned.

The men divided into two parties, the first going to Skelton Grange power station, where all were much impressed, particularly by their hosts' claim to operate for considerable periods at over 100% load factor. Later some wondered whether the same could be done with power factor. Afterwards the party lunched in Leeds as guests of the Yorkshire Division of the Central Electricity Authority. The second party spent an interesting morning at the Yorkshire Switchgear and Electric Company's factory in Leeds followed by lunch as guests of the company.

We joined forces again by 3 p.m. at Fountains Abbey—a magnificent ruin in a most beautiful setting. Here we could follow an excellent guide, or enjoy a quiet wander round on our own. It was a weary party which climbed again into the coaches in the sun-baked car park, but after a pleasant drive to Ripon, we were refreshed by a good tea at the Spa Hotel. In fact, so refreshed were we, that the dinner-dance which followed found us all in splendid form. We were most grateful to our kind hosts, Reyrolle and Co., for the delightful party they gave us. Grateful also to our speakers, Mr. E. N. Robinson and Mr. D. B. Hogg, who were brief, but witty, despite their errors in describing each other's parentage.

Sunday found us all *en route* for York, where the Castle Museum was opened especially for us, and how pleasant it was to have such an enchanting place to ourselves. We could wander round the exhibits as we chose, and even listen to the barrel organ turned by Mrs. Davidson. Once more out in the sunshine we made our way to the Royal Station Hotel, where more kind hosts awaited us. The North Eastern Electricity Board gave us a very pleasant luncheon party before we had to think of our journey home. No visit to York would be complete without seeing the Minster, and the coaches took us there before leaving us at the station, a most fitting end to a most happy Summer Visit. Equally fitting too, the kiss which the Chairman was seen to bestow on one of the ladies as farewells were said on the hotel steps.

M. I. R.

Two views of the party at Fountains Abbey

OLYMPIC GAMES

The Victoria and Tasmania Oversea Committee of The Institution have kindly offered hospitality to all members of The Institution who may be visiting Melbourne during the Olympic Games. Those members who will be in Melbourne at this time are asked to get in touch with the Chairman of the Local Committee, Mr. J. Wilson, Wilson Electric Transformer Co. Pty. Ltd., Wilson Road, Glen Waverley, Victoria, Australia.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH AUGUST 1956

	No. of Contributors	£	s.	d.
£1 000 and over	6	6000	0	0
£100 to <£1 000	29	6386	3	0
£5 to <£100	811	8641	6	3
£2 to <£5	1933	5282	10	8
Under £2	19873	10411	10	2
Totals	22652	£36721	10	1

REVISION OF THE BYE-LAWS

Her Majesty the Queen has now signed an Order in Council approving the proposed changes in the Bye-Laws of The Institution which were this year submitted to the Privy Council. These changes had previously been approved by a Special General Meeting of Corporate Members on the 22nd March 1956. Details of them will be published in a future issue of the *Journal*.

CERTIFICATES OF ASSOCIATESHIP

From time to time requests have been received from Associates of The Institution for some form of certification of their admission to The Institution. The Council have ordered that in view of the importance of this class of membership a Certificate shall be issued on demand. Associates requiring evidence of their membership of that class are therefore invited to write to the Secretary of The Institution for the special form of application which it will be necessary for them to complete before the Certificate can be issued.

TRANSFER TO THE CLASS OF MEMBERS

Candidates for transfer from the class of Associate Members to the class of Members are reminded that they need not complete page 2 of their proposal forms, unless additional academic qualifications have been obtained subsequent to their election to the class of Associate Members. Furthermore, it is only necessary for these candidates to describe, on page 3, their experience subsequent to the date of their election to Associate Membership.

PROGRAMME OF MEETINGS: 1956–57 SESSION

The programme card of London Meetings for the first half of the session is being sent with this issue to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London meetings, may obtain a copy of the London card on application to the Secretary.

MEMBERS' GUESTS

Members are reminded that, under the Bye-laws of The Institution, every member (Students excepted) is entitled to introduce one visitor at each Ordinary Meeting. By direction of the Council, this also applies to all meetings of the Measurement and Control, Radio and Telecommunication, Supply, and Utilization Sections, and to the Informal Meetings.

DISCUSSIONS AT MEETINGS

The Council desire it to be understood that contributions to the discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

Members who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion which will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

CONSUMERS' CONTROL UNITS

Regulation 105 of the Thirteenth Edition of the 'Regulations for the Electrical Equipment of Buildings' states:

> The consumer's main fuse(s) or circuit-breaker may be omitted provided
> (i) the supply undertaking so agrees,
> and (ii) sub-circuit fuse(s) or circuit-breaker(s) providing any necessary further electrical protection are within reach from the main switch.

The Secretary of The Institution has been informed by the Central Electricity Authority on behalf of the Area Boards, and by the South of Scotland Electricity Board and the North of Scotland Hydro-Electric Board that they are prepared to consider sympathetically applications from consumers, or contractors acting on their behalf, to follow the practice authorized in Regulation 105. Furthermore, where installations include a consumer's supply control unit complying with B.S. 1454, 'Consumers' Electricity Control Units', individual applications for authorization need not be made; the foregoing bodies have stated that in such circumstances their agreement to the omission of the main fuse or circuit-breaker may be assumed.

COAT OF ARMS

As a result of the announcement in the June *Journal* that an Institution tie has been introduced, some members have inquired about the possibility of using the Coat of Arms on a blazer badge. After reconsideration of the matter the Council

have reaffirmed their view that it would not be appropriate to do this.

CONVENTION ON DIGITAL-COMPUTER TECHNIQUES

An order form for the special Supplements to the *Proceedings* containing the addresses, papers and discussions at the Convention on Digital-Computer Techniques has been sent to all subscribers to Part B of the *Proceedings*. Any members or others who do not subscribe to this Part may obtain a copy of the order form on application to the Secretary. It is expected that the Supplements (three in number) will be issued at monthly intervals in September, October and November, the price to members being 10s. each, or £1 7s. 6d. for the complete set, and to non-members £1 each, or £2 15s. for the complete set.

Those who have already ordered copies on the registration form issued in advance of the Convention are not required to take any further action.

CONVENTION ON ELECTRICAL EQUIPMENT OF AIRCRAFT

An order form for copies of the special Supplement relating to the Convention on Electrical Equipment of Aircraft has been sent to all subscribers to Part A of the *Proceedings*. Any members or others who do not subscribe to this Part may obtain a copy of the order form on application to the Secretary. It is expected that the Supplement will be issued in December, the price to members being 15s., and to non-members £1 10s.

Those who have already ordered copies on the registration form issued in advance of the Convention are not required to take any further action.

IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

In the list of Officers on page 436 of the July *Journal* the name of the Chairman of the Iraq and Persian Gulf Joint Oversea Group was shown incorrectly; the present Chairman of the Group is, in fact, Mr. J. D. Addison, M.I.MECH.E., MEMBER.

SPECIAL COURSES IN HIGHER TECHNOLOGY

A programme of specialized courses starting in September and October at technical colleges in London and the Home Counties for the Autumn term, 1956, has been issued by the London and Home Counties Regional Advisory Council. The bulk of these courses are part-time, mostly evening classes, but a few full-time courses of not more than three months' duration are included. The courses cover a very wide range of specialized aspects of electrical and mechanical engineering, mathematics, physics, chemistry, metallurgy, management, industrial law, engineering economics, organization, statistics, etc. They cover the latest techniques used in industry, including subjects such as automation, digital computers and microwaves.

Details of a particular course and the date of registration may be obtained from the college in question. The fees for these advanced courses are usually 10s. for six lectures, up to a maximum of £2.

Those interested will find further details in the 'Bulletin of Special Courses in Higher Technology', issued by the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1, price 1s. 6d., post free.

POSTGRADUATE COURSES IN SCIENCE

UNIVERSITY OF LIVERPOOL: 1956–57 SESSION

The postgraduate courses in science which have been arranged by the University of Liverpool, Department of Extra-Mural Studies, during the autumn and winter of 1956–57 include series of lectures on the following subjects: Recent Advances in Electronic Techniques; Electronic Analogue Computers; and Nuclear Engineering. The lectures will be given by engineers and physicists on the staff of the University, and from industry. Full particulars of the courses can be obtained from the Director of Extra-Mural Studies, 9 Abercromby Square, Liverpool, 7. Those interested should apply forthwith, since intending students for the autumn term are asked to enrol by the 1st October 1956.

STUDENTS' QUARTERLY JOURNAL

The contents of the September issue of the *Students' Quarterly Journal* include the following items:

'The Metal Rectifier', by D. Mangnall.
'Linear Accelerators', by J. C. Hopkins, B.SC.
'Experiences in Denmark', by A. Hughes, B.ENG.
'Electrical Storage Heating', by J. Eddyshaw.
'Arc Furnaces', by C. F. R. Bradshaw, B.ENG.
'Electricity as an Aid to Coalmining', by R. Quayle and R. Strong.
'Cybernetics', by K. I. Gordon.
'Naval Electrics', by R. M. Rennie.
'Power System Control and Communication', by M. A. Pai, B.E.

In addition there are brief notes introducing Mr. W. H. Dunkley and Dr. M. V. Wilkes, who will be delivering the Students' Lectures during 1956–58.

DEFERMENT OF ELECTRICAL TECHNICIANS

The following is an extract from a letter which has been received from the Minister of Labour and National Service in response to a request from the Council for facilities for the deferment of electrical technician trainees.

It has been decided, and the National Service Deferment Boards are being advised accordingly, to allow deferment to trainee technicians in all branches of engineering for the period necessary to complete up to five years' practical training from the minimum age of 16, if the Boards are satisfied that the applicant is a bona fide apprentice (not necessarily by reason of a written agreement) and is following a planned syllabus of training. The precise nature of the specialist training must necessarily be influenced by the field of engineering with which the employer is concerned. The apprentice would be required to undertake part-time studies by attending day or evening classes (where available) in suitable subjects leading to a City and Guilds Certificate, National Certificate or other appropriate qualification.

In assessing the merits of individual applications for deferment in the various branches of engineering, the National Service Deferment Boards will have, for reference when required, the reports of the Ministry's Technical Officers on the training arrangements at the employers' establishments.

The grant of deferment under these arrangements is, of course, an interim measure, and subject to review in the light of the provisions of any scheme which the representatives of the engineering industry might elect to introduce at some future date.

It is hoped that this decision will go some long way to encourage the proper training of technicians generally and to deal with the problems of the electrical engineering industry to which you referred in your letter.

SYMPOSIUM ON AERONAUTICAL COMMUNICATIONS

UTICA: OCTOBER 1956

The I.R.E. Professional Group on Communications Systems are organizing a symposium on the 8th–10th October 1956 that will discuss communication in support of systems in relation to present and future aeronautical activities. The symposium will be held in Utica, New York State, and will be open to anyone wishing to attend. Further information may be obtained from the Secretary, The Institute of Radio Engineers Inc., 1 East 79 Street, New York 21, N.Y.

KING GEORGE VI MEMORIAL FELLOWSHIPS

The English-Speaking Union of the United States again offers between 25 and 30 Fellowships to enable British men and women between 18 and 30 years of age to study at American universities and technical institutions during the academic year 1957–58. Each Fellowship is worth $2 500 plus the fees for tuition and the cost of travel to and from the United States. The awards are open both to university graduates and to holders of the Higher National Certificate, or students who are candidates for these examinations in the summer of 1957. A few of the Fellowships are reserved for Australia and New Zealand. The last date for applications is the 10th November 1956. Full details and application forms may be obtained from Mrs. D. R. Dalton, B.A., King George VI Memorial Fellowships Committee, 37 Charles Street, Berkeley Square, London, W.1.

SYMPOSIUM ON OPTICS AND MICROWAVES

WASHINGTON: NOVEMBER 1956

A symposium sponsored by the I.R.E. Professional Group on Antennas and Propagation, the George Washington University and the Optical Society of America, on the subject of optics and microwaves will be held at the George Washington University, Washington, D.C., on the 14th–16th November 1956. The aim of this symposium is to promote interest in the common problems of optics and microwaves, and to demonstrate that these lie within the scope of modern theoretical and practical optics. Further information may be obtained from the Secretary, The Institute of Radio Engineers Inc., 1 East 79 Street, New York 21, N.Y.

NEWS *from Abroad*

BRISBANE

QUEENSLAND COMMITTEE

On the 14th June 1956 a meeting was held in Brisbane to hear a paper by Mr. R. T. Hinkley, entitled *Impressions of a Visit to some Electricity Undertakings in England and on the Continent of Europe*. Mr. Hinkley is the Acting Professor of Electrical Engineering at the University of Queensland. Invitations were extended to the Institution of Engineers, Australia, and to the various supply authorities in Brisbane.

Mr. Hinkley's visit oversea took him to the United Kingdom and to Sweden, France and Switzerland. He expressed very deep appreciation of the courtesy extended to him everywhere by both commercial organizations and public authorities.

Mr. Hinkley referred to developments in nuclear physics and, to emphasize the importance of this new source of energy in the relatively near future, he quoted some startling figures on growth of power generation in relation to available fuel resources.

He discussed the effect on distribution systems of the area served, showing how, in the more concentrated districts of Britain, with shorter transmission distances, the tendency towards very high voltages had been less pronounced than in larger countries such as Sweden and France, which have longer transmission lines. In addition, some of the problems of large high-voltage networks were explained, particularly those of control, space for substations, and devices for economy in the use of expensive plant.

Mr. Hinkley also touched on automation, with particular reference to its use in the chemical and oil industries, semiconductors, and on lightning research, the last being of particular interest because of the work being done in this field by Professor Prentice at our own University in Queensland.

The meeting, which was under the control of the Chairman of the Local Committee, Mr. A. S. Faulkner, was very well attended. After a short discussion period, Mr. J. E. Morwood proposed a vote of thanks. W. I. G.

INDIA

MADRAS COMMITTEE

During 1955, the Madras Oversea Committee of The Institution arranged eight meetings and visits. These included a lecture by Mr. F. H. Sharpe, of a British firm of consulting engineers, on *Economics of Switchgear in Transmission Systems*, which was attended by sixty-nine people, including guests from the Madras Government Electricity Department; a showing of the film on the Owen Falls scheme, provided by the British Information Services; and lectures by Mr. N. V. Kudva and Mr. B. S. Pradhan, both of a Madras textile firm, on *Electronics in Industry* and *Location of Underground Cable Faults*. At the last meeting of the year on the 18th November, Mr. E. T. Metcalf, who was visiting India from England, gave a lecture on *The Influence of Hydraulic Conditions on the Design of Waterwheel Alternators*; this took place in the hall of the Institution of Engineers (India), and thirty-five members were present.

In 1955 the first stage of the Machkund hydro-electric scheme for supplying power to Andhra State was completed. The scheme harnesses the waters of the Machkund river, a sub-tributary of the River Godavari, which forms the boundary line between Andhra and Orissa States; this lies in the western part of central India, at the Duduma Falls in the Koraput District of Orissa. The construction of the scheme was started in 1946 as a post-war development scheme of the composite Madras State. The first stage of the scheme provides for the installation of three generating units, each of 17 000 kW and directly coupled to a 25 000 h.p. Francis vertical reaction-type turbine; these were made in the United States. The voltage generated is stepped up from 11 kV to 132 kV through banks of single-phase 6670 kVA British transformers, located in an outdoor yard, and connected to the generators on the unit system. The machines are paralleled on the high-voltage side. The gross head is 850 ft, and the penstock consists of six pipes of about 5 ft diameter, and 1 054 ft in length. The ultimate generating capacity of the scheme will be 102 000 kW.

R. W.

OVERSEA ATTENDANCE REGISTER

During the period 1st July to 31st July 1956, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

ALEONG, R. V. S. (Trinidad).
BELLAMY, R. F. (Malta).
BOZZOLI, G. R., D.SC.(ENG.) (Johannesburg).
BROOKS, A. H. (Lagos).
BROWN, P. T. P. (Rio de Janeiro).
COOKE, D. R. (Trinidad).
DE NORDWALL, Col. C. H. (Rio de Janeiro).
FONG, S. H. (Perak, Malaya).
FUAD, I. (Cairo).
GILLMAN, G. A. (Madrid).
HAYWARD, G. B., M.B.E., B.A. (Athens).
HENRIQUES-PINHEIRO, J. M. (Lisbon).
HENWOOD, W. J. (Nkana, N. Rhodesia).
HOFFENBERG, M. S., M.SC.(ENG.) (Johannesburg).
OFFORD, R. E. G., B.SC. (Umtali S. Rhodesia).
REAY, D. B., D.SC.(ENG.), B.SC.(ENG.) (Johannesburg).
SINGH, K. (Kuala Lumpur).
SOMERVILLE, A. W. M. (Johannesburg).
SEEHRA, K. S. (Bombay).
TYACKE, J. A., B.SC.TECH. (Ipoh, Malaya).
WILSON, M., M.A. (Pietermaritzburg Natal).

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R. B. COX, B.SC., AND J. WALKER, M.A.
September 1956 **The Control of Nuclear Reactors** (PAPER NO. 2068 M, MARCH 1956)

W. ABSON, B.SC., AND F. WADE
September 1956 **Nuclear-Reactor-Control Ionization Chambers** (PAPER NO. 2029 M, MARCH 1956)

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F. C. MCLEAN, C.B.E., B.SC., A. N. THOMAS, AND R. A. ROWDEN, B.SC.(ENG.)
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V. J. COOPER, B.SC.(ENG.), AND W. J. MORCOM, B.SC.(ENG.), WH.SC.
August 1956 **Band I Television-Transmitter Design, with particular reference to the Transmitters at Crystal Palace** (PAPER NO. 2075 R, MARCH 1956)

M. R. CHILD
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H. SUTCLIFFE, M.A.
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